CCAMLR

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Final report of research fishing operations at Subarea 48.6 between the 2012/13 and 2020/21 fishing seasons

Delegations of Japan, Spain and South Africa

EN

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Abstract

This paper represents the final report of a multi-member longline survey on Antarctic toothfish (*Dissostichus mawsoni*) at Subarea 48.6 between 2018/19 and 2020/21 fishing seasons by Japan, Spain, and South Africa. This survey period is the third of three seasons research at the Subarea 48.6; 1st: 2012/13-2014/15, 2nd: 2015/16-2017/18, 3rd: 2018/19-2020/21. The data set, C2 and Observer data, was provided by the CCAMLR Secretariat on the 14th July, 2020. This report summarizes fishing activity, collected data, and progress and achievements of each objective.

In this paper, the data set during current fishing season (2020/21) was used for reporting the quantity of data and samples collected. The research operations at 48.6 have not yet been completed in the 2020/21 fishing season.

Fishing activity

Fishing effort

One fishing cruise by Japanese vessel (Shinsei-Maru No.8), and one fishing cruise by Spanish vessel (Tronio) took place at Subarea 48.6 in the 2020/21 season. Shinsei-Maru No.8 has operated with Trotline as the longline fishing gear from January to March. Tronio has operated with Spanish line from February to April. Because of heavy sea ice, both Shinsei-Maru No. 8 and Tronio could not complete the fishing operation at the research blocks 4 and 5 during 2020/21 fishing season. It is noted that the research operations at 48.6 have not yet been completed in the 2020/21 fishing season.

Number of lines for each vessel by fishing season is summarized in Table 1. Table 2 summarizes the number of lines per fishing season and research block for each vessel. Figure 1 indicates the spatial distribution of operated lines since 2012/13 fishing season. Figures 2 and 3 indicate the spatial distribution and depth distribution of operated lines for each fishing season since 2012/13 fishing season, respectively. Due to the changes in the design of the research blocks over the years, some of the lines fall outside the research blocks 2-5.

Table 1: Numbers of lines for each vessel by fishing season (pooled across Subareas) in Subarea 48.6. Season is abbreviated to the end year.

Member	Vessel	Fishing System	2013	2014	2015	2016	2017	2018	2019	2020	2021
ESP	Tronio	spanish							150	122	118
JPN	Shinsei Maru No. 3	trotline	179	87	120	179	194	209	163	89	
JPN	Shinsei Maru No. 8	trotline									106
ZAF	Koryo Maru No. 11	trotline	185	41	52	154	110	198		136	

Table 2: Number of lines per fishing season, vessel, and research block in Subarea 48.6 between 2012/13 to 2020/21 fishing season. Values of "Outside" includes operations in the research blocks 48.6_1 in 2012/13 and 2015/16 seasons.

Season	Member	Vessel	486_2	486_3	486_4	486_5	Outside
2013	JPN	Shinsei Maru No. 3	100	6	57		16
2013	ZAF	Koryo Maru No. 11	94	8	70		13
2014	JPN	Shinsei Maru No. 3	74	13			
2014	ZAF	Koryo Maru No. 11	41				
2015	JPN	Shinsei Maru No. 3	58	7	55		
2015	ZAF	Koryo Maru No. 11	24	17	11		
2016	JPN	Shinsei Maru No. 3	81	22	46		30
2016	ZAF	Koryo Maru No. 11	61	26	67		
2017	JPN	Shinsei Maru No. 3	88	18	10	78	
2017	ZAF	Koryo Maru No. 11	59	28	23		
2018	JPN	Shinsei Maru No. 3	76	19	23	91	
2018	ZAF	Koryo Maru No. 11	89	15	94		
2019	ESP	Tronio	48	7	63	32	
2019	JPN	Shinsei Maru No. 3	103	5	38	17	
2020	ESP	Tronio	47	7	27	41	
2020	JPN	Shinsei Maru No. 3	12	5	50	22	
2020	ZAF	Koryo Maru No. 11	41	11	84		
2021	ESP	Tronio	21	12	33	52	
2021	JPN	Shinsei Maru No. 8	13	6	72	15	

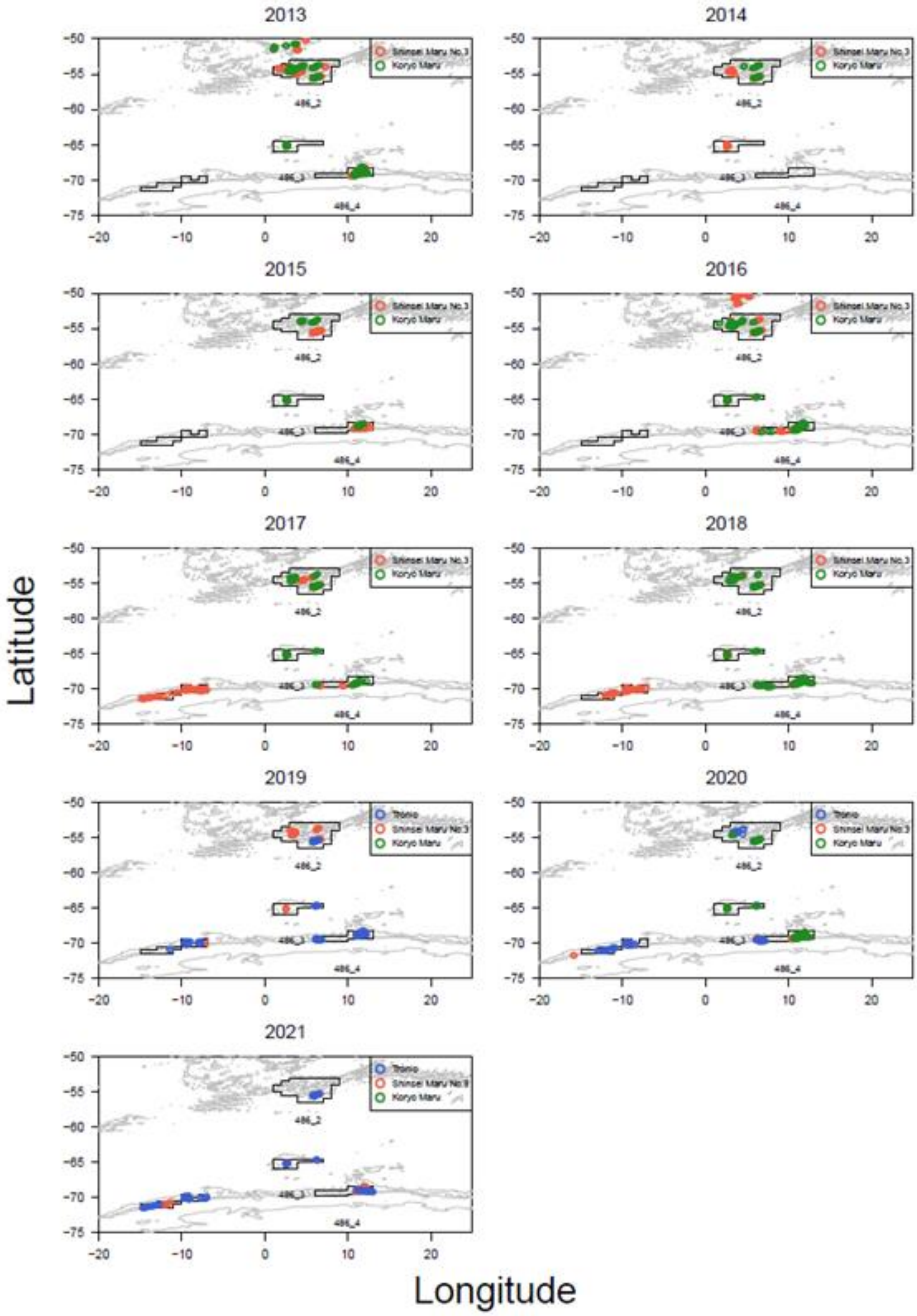


Fig. 1: Spatial distribution of individual lines in Subarea 48.6 since the 2012/13 fishing season. Black lines = CCAMLR Research Blocks, grey line = bathymetry contours 1000, 2000, and 3000 m obtained by ETOPO1. In 2019/20 fishing season, fishing locations outside of the research block 48.6_5 were notified to the Secretariat as “Buffer zone” and “Extended buffer zone” on 30th-31st January 2020 in accordance with the Annex 41-01/B.

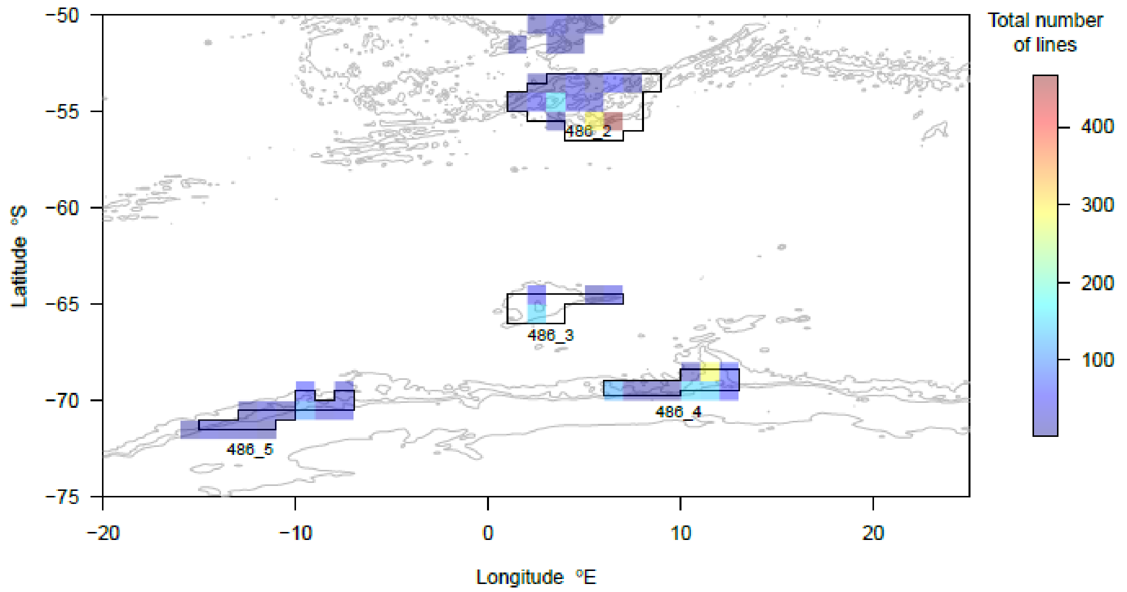


Fig. 2: Spatial distribution of fishing effort at Subarea 48.6 since the 2012/13 fishing season. Shading indicates the number of longlines deployed. Raster cells are of size 0.2 degree longitude and 0.2 degree latitude. Black lines = CCAMLR Research Blocks, grey line = bathymetry contours 1000, 2000, and 3000 m obtained by ETOPO1.

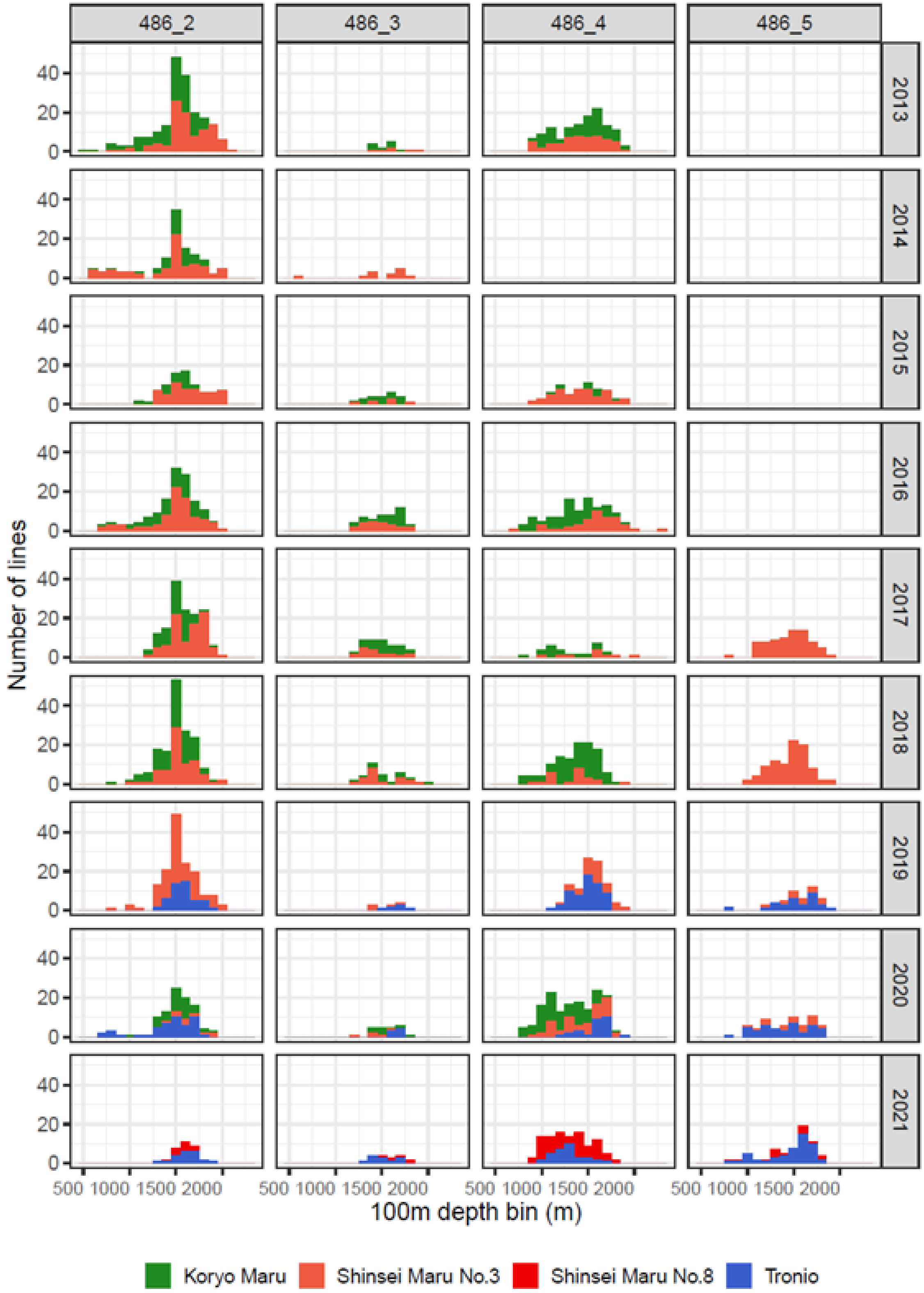


Fig. 3: Depth ('depth_gear_set_start_m' in CCAMLR data) distribution of lines in Research Blocks of Subareas 48.6 since 2012/13 fishing season.

Catch amount

In 2020/21 season, total catches of *D. mawsoni* were 319 tonnes in Subarea 48.6 (Table 3), it is noted that the research operations in Subarea 48.6 have not yet been completed. Depth distribution of catch is shown in Figure 4.

Table 3: Summary of total catches (t) of *D. mawsoni* across research blocks and seasons in Subarea 48.6.

48.6_2	2013	2014	2015	2016	2017	2018	2019	2020	2021
Koryo Maru No. 11	23.07	10.82	7.96	24.15	78.82	78.10	NA	16.71	NA
Shinsei Maru No. 3	89.64	84.40	74.24	59.01	89.09	70.01	109.17	11.21	NA
Shinsei Maru No. 8	NA	NA	NA	NA	NA	NA	NA	NA	31.21
Tronio	NA	NA	NA	NA	NA	NA	56.61	42.06	37.24

48.6_3	2013	2014	2015	2016	2017	2018	2019	2020	2021
Koryo Maru No. 11	24.95	NA	23.84	22.44	19.72	16.77	NA	12.66	NA
Shinsei Maru No. 3	24.97	49.92	25.01	27.30	30.10	23.15	15.37	11.87	NA
Shinsei Maru No. 8	NA	NA	NA	NA	NA	NA	NA	NA	14.84
Tronio	NA	NA	NA	NA	NA	NA	16.51	12.72	14.90

48.6_4	2013	2014	2015	2016	2017	2018	2019	2020	2021
Koryo Maru No. 11	39.18	NA	4.83	50.11	11.04	72.78	NA	52.87	NA
Shinsei Maru No. 3	73.53	NA	51.63	49.07	16.80	30.80	29.30	53.80	NA
Shinsei Maru No. 8	NA	NA	NA	NA	NA	NA	NA	NA	80.41
Tronio	NA	NA	NA	NA	NA	NA	47.84	17.54	27.63

48.6_5	2013	2014	2015	2016	2017	2018	2019	2020	2021
Koryo Maru No. 11	NA	NA	NA	NA	NA	NA	NA	NA	NA
Shinsei Maru No. 3	NA	NA	NA	NA	189.91	225.43	40.37	35.80	NA
Shinsei Maru No. 8	NA	NA	NA	NA	NA	NA	NA	NA	25.31
Tronio	NA	NA	NA	NA	NA	NA	60.79	66.13	87.35

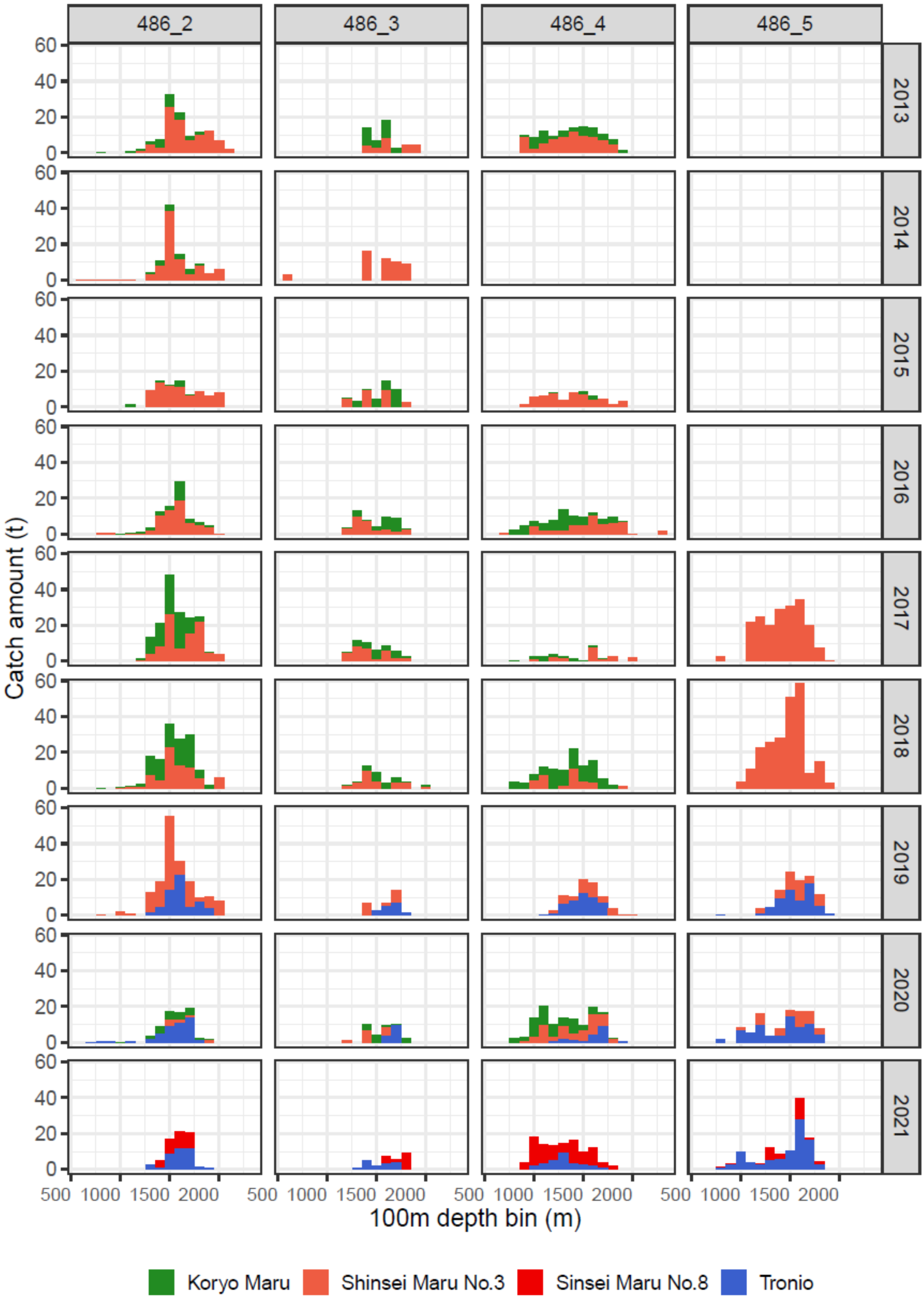


Fig. 4: Accumulated Catch amount (t) of *D. mawsoni* by depth bin (100m) in each research block at Subarea 48.6 since 2012/13 fishing season.

CPUE

Figure 5 represents the spatial distribution of *D. mawsoni* catch per unit effort (CPUE) calculated as catch amount (t) per 1000 hooks. Figure 6 shows the Time series of CPUE (kg/1000 hooks) of *D. mawsoni* in Subarea 48.6 since 2007/08 fishing season.

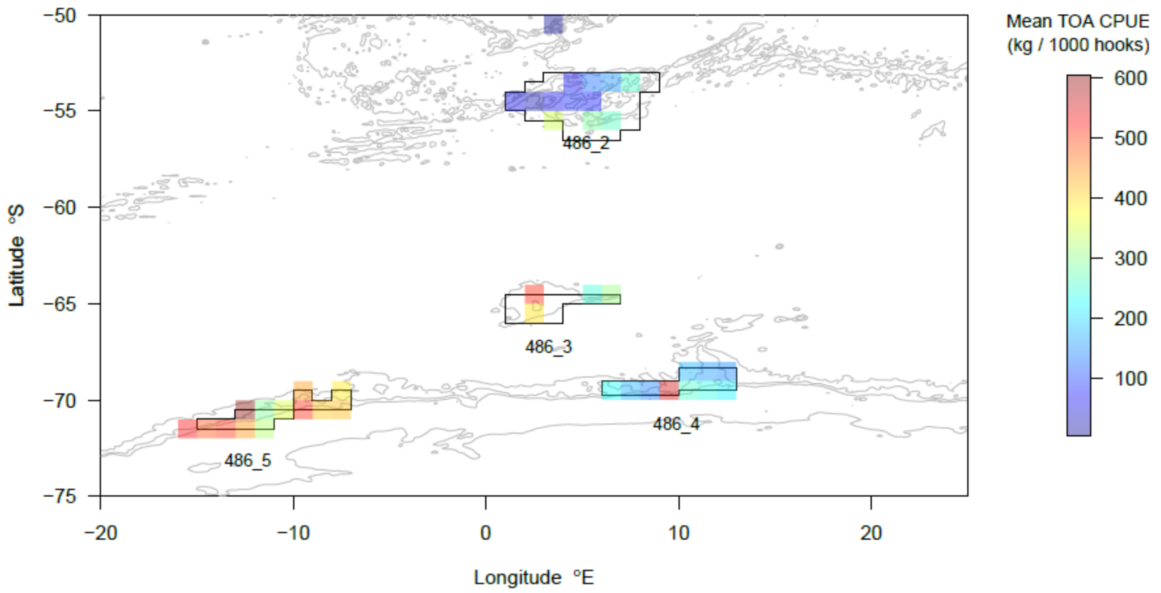


Fig. 5: Spatial distribution of CPUE (kg/1000 hooks) of *D. mawsoni* in Subarea 48.6 since 2012/13 fishing season. Square cells are of size 0.2 degree longitude and 0.2 degree latitude. Black lines = CCAMLR Research Blocks, grey line = bathymetry contours 1000, 2000, and 3000 m obtained by ETOPO1.

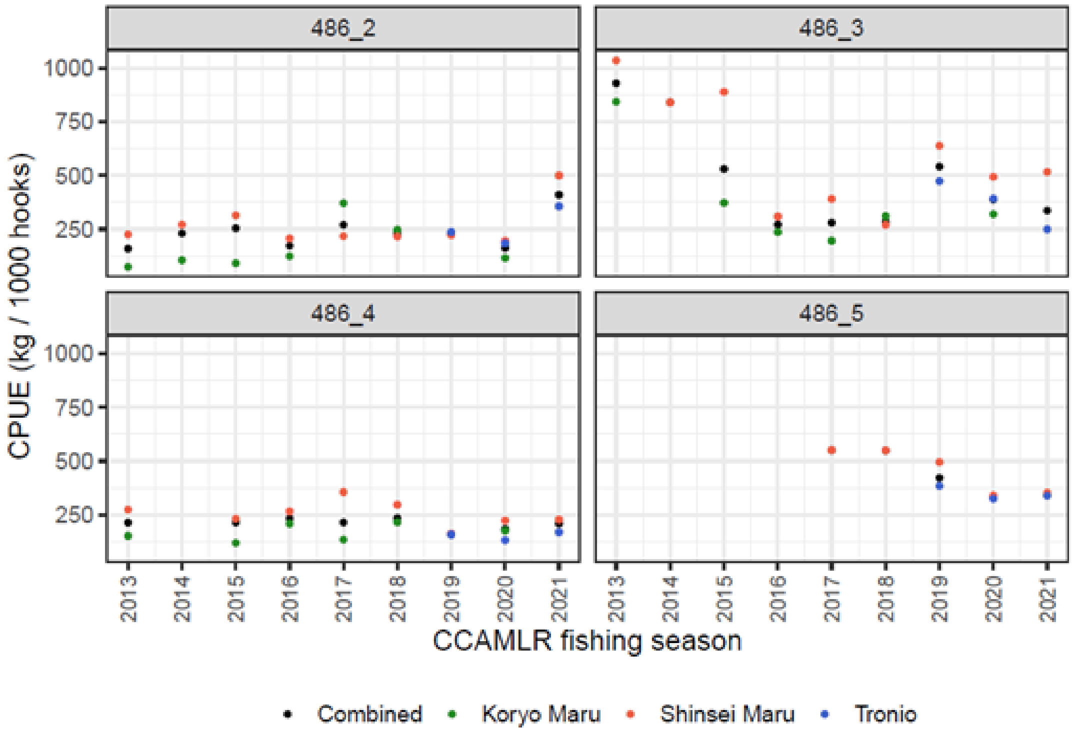


Fig. 6: Time series of CPUE (kg/1000 hooks) of *D. mawsoni* in Subarea 48.6. 'Combined' CPUE is calculated from overall catch amount and line length of each research block in Subarea 48.6.

Biological sampling

Sampling summary for biological information of *D. mawsoni* caught in Subarea 48.6 was indicated by Table 4. Since the research operations in Subarea 48.6 have not yet been completed in the 2020/21 fishing season, the number of observed fish and sample collection will be increased during this fishing season.

Table 4: Summary table of *D. mawsoni* biological data in Subarea 48.6. Values are the number of fish observed for each biological parameter and sample collection. Data are for all vessels and cruises pooled. Season is abbreviated to the end year.

Research Block	Season	Length	Weight	Sex	Maturity	Gonad	Otolith
486_2	2013	2925	2504	2718	2716	2718	1249
486_2	2014	2324	1613	1680	1682	1682	676
486_2	2015	2044	1682	1682	1687	1687	738
486_2	2016	1869	1869	1858	1860	1860	1370
486_2	2017	3633	3048	3045	3045	3045	2168
486_2	2018	3198	3198	3198	3198	3198	1405
486_2	2019	3360	3360	3347	3360	3360	2512
486_2	2020	1575	1575	1575	1575	1575	747
486_2	2021	994	973	992	993	993	349
486_3	2013	1101	723	402	401	402	142
486_3	2014	994	416	391	391	391	130
486_3	2015	940	573	573	573	573	203
486_3	2016	896	896	892	893	894	676
486_3	2017	857	857	857	857	857	510
486_3	2018	774	774	764	764	764	333
486_3	2019	446	446	446	446	446	220
486_3	2020	637	637	637	637	637	233
486_3	2021	493	485	493	493	493	198
486_4	2013	2675	2359	2213	2213	2213	1100
486_4	2015	1470	1326	1325	1325	1325	625
486_4	2016	2155	2155	2151	2152	2152	1479
486_4	2017	633	633	633	633	633	272
486_4	2018	2201	2201	2180	2180	2180	1037
486_4	2019	1340	1340	1340	1339	1339	1027
486_4	2020	2860	2860	2859	2858	2858	1483
486_4	2021	2472	2438	2462	2472	2472	1240
486_5	2017	2191	2191	2178	2191	2191	758
486_5	2018	2922	2911	2911	2922	2922	906
486_5	2019	1281	1281	1273	1272	1272	736
486_5	2020	1865	1865	1865	1865	1865	798
486_5	2021	1899	1898	1899	1899	1899	776
Outside	2013	1	0	0	0	0	0

Tagging

Number of *D. mawsoni* tagged is shown in Table 5. Spatial distribution of released and recaptured *D. mawsoni* is shown in Figure 7. Table 6 indicates summary of tagged and recaptured information between 2012/13 and 2020/21 fishing season.

Shinsei Maru No.8 released PSATs (MiniPAT, Wildlife computers) in Subarea 48.6 in 2020/21 fishing season (see details in the section "Achievement of milestones for research objectives").

Table 5: Number of tagged and released *D. mawsoni* in Subarea 48.6 since 2012/13 fishing season. The tag overlap statistics "theta" (determined in CM 41-01) was calculated for all over Subarea and for each research block.

Year	Vessel	Overall theta	Tags in 48.6_2	(Theta)	Tags in 48.6_3	(Theta).1
2013	Koryo Maru No. 11	64.06	118	62.72	125	54.12
2013	Shinsei Maru No. 3	71.51	453	72.31	147	73.96
2014	Koryo Maru No. 11	73.67	57	73.67	NA	NA
2014	Shinsei Maru No. 3	77.12	426	73.96	266	79.34
2015	Koryo Maru No. 11	84.89	42	65.40	125	83.29
2015	Shinsei Maru No. 3	83.87	379	76.44	278	88.08
2016	Koryo Maru No. 11	67.85	126	66.43	121	62.26
2016	Shinsei Maru No. 3	79.70	298	70.79	182	88.86
2017	Koryo Maru No. 11	76.42	414	73.78	100	76.54
2017	Shinsei Maru No. 3	63.93	458	61.57	165	78.56
2018	Koryo Maru No. 11	71.12	426	77.27	90	73.15
2018	Shinsei Maru No. 3	74.38	391	74.20	118	75.91
2019	Shinsei Maru No. 3	72.58	575	73.24	80	56.72
2019	Tronio	68.44	237	60.47	126	87.52
2020	Koryo Maru No. 11	60.12	90	51.01	65	77.62
2020	Shinsei Maru No. 3	70.28	61	66.52	63	63.19
2020	Tronio	66.48	209	60.92	67	65.88
2021	Shinsei Maru No. 8	75.76	166	73.77	78	69.82
2021	Tronio	64.85	186	55.86	76	66.88

Year	Vessel	Overall theta	Tags in 48.6_4	(Theta)	Tags in 48.6_5	(Theta).1
2013	Koryo Maru No. 11	64.06	199	57.85	NA	50.00
2013	Shinsei Maru No. 3	71.51	369	65.34	NA	50.00
2014	Koryo Maru No. 11	73.67	NA	NA	NA	NA
2014	Shinsei Maru No. 3	77.12	NA	NA	NA	NA
2015	Koryo Maru No. 11	84.89	23	69.43	NA	50.00
2015	Shinsei Maru No. 3	83.87	266	71.99	NA	50.00
2016	Koryo Maru No. 11	67.85	256	62.37	NA	50.00
2016	Shinsei Maru No. 3	79.70	251	74.05	NA	50.00
2017	Koryo Maru No. 11	76.42	63	73.06	NA	50.00
2017	Shinsei Maru No. 3	63.93	100	55.68	961	48.11
2018	Koryo Maru No. 11	71.12	370	60.87	NA	50.00
2018	Shinsei Maru No. 3	74.38	176	61.49	1136	43.65
2019	Shinsei Maru No. 3	72.58	160	59.64	206	48.89
2019	Tronio	68.44	225	59.94	326	61.13
2020	Koryo Maru No. 11	60.12	270	42.73	NA	50.00
2020	Shinsei Maru No. 3	70.28	270	70.39	183	56.69
2020	Tronio	66.48	88	50.32	332	88.75
2021	Shinsei Maru No. 8	75.76	409	71.90	128	62.20
2021	Tronio	64.85	142	58.37	441	48.35

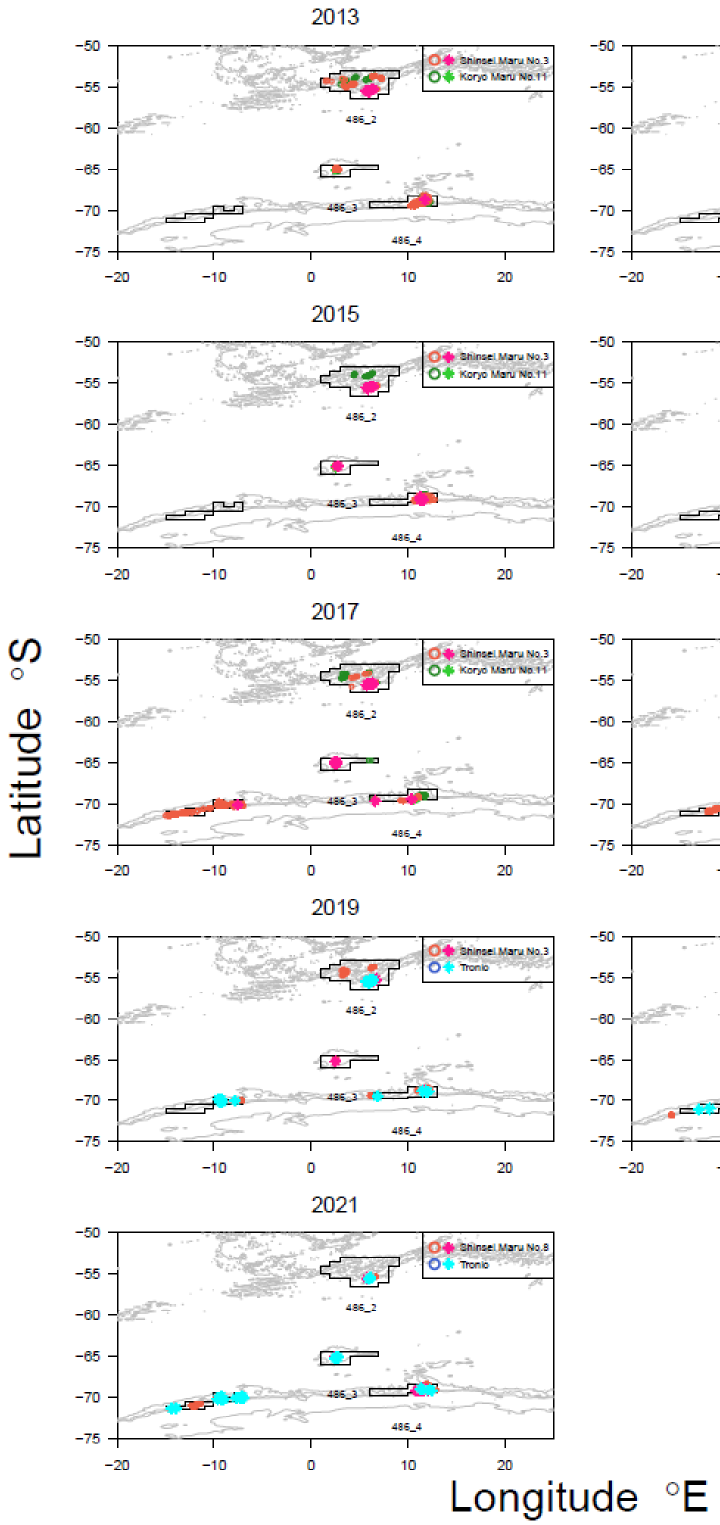


Figure 7: Spatial distribution of released and recaptured *D. mawsoni* in Subarea 48.6 since 2012/13 fishing season. Circles indicate locations of released fishes and recaptured fishes inasterisks . Black lines = CCAMLR Research Blocks, gray lines = bathymetry contours 1000, 2000, and 3000 m obtained by ETOPO1. In 2019/20 fishing season, fishing locations at outside of the research block 48.6_5 were notified to the Secretariat as "Buffer zone" and "Extended buffer zone" on 30th-31st January 2020 in accordance with the Annex 41-01/B.

Table 6: Summary of tagged and recaptured information in Subarea 48.6. Labels in rows and columns indicate CCAMLR fishing season (e.g., 2013: 2012/13 season). Years in row are released year. Years in column are recaptured year.

48.6_2	No. Released	2013	2014	2015	2016	2017	2018	2019	2020	2021
2013	571	5	7	0	2	0	0	0	0	0
2014	483	-	5	3	1	0	0	0	0	0
2015	421	-	-	2	5	6	1	0	0	0
2016	424	-	-	-	1	14	2	1	0	0
2017	872	-	-	-	-	19	27	19	2	0
2018	817	-	-	-	-	-	22	55	11	0
2019	812	-	-	-	-	-	-	18	16	1
2020	360	-	-	-	-	-	-	-	4	3
2021	352	-	-	-	-	-	-	-	-	1

48.6_3	No. Released	2013	2014	2015	2016	2017	2018	2019	2020	2021
2013	272	0	0	2	0	0	0	0	0	0
2014	266	-	0	2	2	0	0	0	0	0
2015	403	-	-	2	5	2	0	0	0	0
2016	303	-	-	-	7	6	0	0	0	0
2017	265	-	-	-	-	5	3	0	0	2
2018	208	-	-	-	-	-	1	1	0	1
2019	206	-	-	-	-	-	-	0	1	0
2020	195	-	-	-	-	-	-	-	1	2
2021	154	-	-	-	-	-	-	-	-	2

48.6_4	No. Released	2013	2014	2015	2016	2017	2018	2019	2020	2021
2013	568	1	NA	1	6	1	1	1	0	2
2014	NA	-	NA	NA	NA	NA	NA	NA	NA	NA
2015	289	-	-	0	3	0	3	0	1	1
2016	507	-	-	-	1	2	4	0	2	3
2017	163	-	-	-	-	0	0	0	0	1
2018	546	-	-	-	-	-	3	2	5	7
2019	385	-	-	-	-	-	-	3	2	2
2020	628	-	-	-	-	-	-	-	0	2
2021	551	-	-	-	-	-	-	-	-	2

48.6_5	No. Released	2013	2014	2015	2016	2017	2018	2019	2020	2021
2013	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2014	NA	-	NA	NA	NA	NA	NA	NA	NA	NA
2015	NA	-	-	NA	NA	NA	NA	NA	NA	NA
2016	NA	-	-	-	NA	NA	NA	NA	NA	NA
2017	961	-	-	-	-	1	4	2	2	6
2018	1136	-	-	-	-	-	3	3	7	4
2019	532	-	-	-	-	-	-	3	2	3
2020	515	-	-	-	-	-	-	-	3	2
2021	569	-	-	-	-	-	-	-	-	4

Non-target species

Table 7 shows summary of bycatch weight except for VME species recorded in C2 across research blocks and fishing seasons in Subarea 48.6.

Table 7: Summary of catch weight (kg) of non-target species except for VME species recorded in C2 across research blocks and fishing seasons in Subarea 48.6.

RB	Taxon	2013	2014	2015	2016	2017	2018	2019	2020	2021
486_2	ANT	408.20	220.2	216.10	270.75	165.65	228.05	194.40	50.69	3.30
486_2	GRV	4187.89	1523.2	656.85	2749.05	1394.10	2779.03	2077.96	806.94	35.40
486_2	ICX	8.50	NA	NA	NA	NA	NA	NA	NA	NA
486_2	KCF	NA	NA	NA	NA	NA	NA	NA	NA	NA
486_2	MOY	NA	NA	NA	NA	NA	NA	NA	3.40	NA
486_2	MRL	2.02	13.1	0.25	8.91	2.20	1.56	6.16	1.60	0.20
486_2	NOK	NA	NA	NA	4.50	NA	NA	NA	NA	NA
486_2	NOX	NA	1.4	NA	NA	NA	NA	NA	NA	NA
486_2	TOP	NA	NA	NA	5383.38	NA	5866.94	5891.44	4452.20	23.00
486_3	ANT	25.70	40.8	96.80	63.95	105.00	82.10	22.85	44.27	55.55
486_3	GRV	622.20	463.3	677.40	1574.90	1923.00	1007.86	384.60	407.08	658.70
486_3	MOY	NA	NA	NA	NA	NA	NA	NA	NA	47.30
486_3	MRL	1.20	0.2	0.80	1.60	12.10	6.19	10.50	5.54	2.50
486_3	TOP	NA	NA	NA	NA	NA	20.57	NA	NA	NA
486_4	ANT	1306.60	NA	486.30	362.50	230.60	786.14	745.15	1247.19	1237.40
486_4	FIC	0.40	NA	NA	NA	NA	100.50	NA	NA	NA
486_4	GRV	12235.45	NA	3308.05	4809.19	2185.00	4625.40	2119.33	6749.04	6815.48
486_4	ICX	207.85	NA	253.90	233.55	102.10	122.41	18.28	62.95	662.00
486_4	MOY	NA	NA	NA	NA	NA	NA	7.00	4.00	114.00
486_4	MRL	47.70	NA	23.70	16.20	30.80	20.96	0.20	113.90	121.19
486_4	SSX	NA	NA	NA	0.03	NA	NA	NA	NA	NA
486_4	TOP	NA	NA	110.69	50.13	NA	136.30	NA	NA	18.79
486_5	ANT	NA	NA	NA	NA	226.00	486.27	100.79	162.04	262.40
486_5	GRV	NA	NA	NA	NA	2863.60	6926.50	1731.62	1578.88	2558.42
486_5	ICX	NA	NA	NA	NA	551.60	824.39	34.67	34.44	378.65
486_5	MOY	NA	NA	NA	NA	NA	NA	NA	11.90	14.10
486_5	MRL	NA	NA	NA	NA	4.10	6.19	NA	1.98	4.88
486_5	SSX	NA	NA	NA	NA	0.02	0.01	NA	NA	NA
486_5	TOP	NA	NA	NA	NA	NA	186.00	NA	NA	NA

VME

Table 8 shows total weight of VME indicator species caught during research fishing in Subarea 48.6 since 2012/13 fishing seasons. Spatial distribution of VME indicator species by each haul is shown in Appendix Figures.

Table 8: Summary of catch weight (kg) of VME species recorded by scientific observers in Subarea 48.6 since 2012/13 fishing season.

RB	Taxon	2013	2014	2015	2016	2017	2018	2019	2020	2021
486_2	AJZ	0.050	NA	NA	NA	0.050	NA	NA	0.285	0.100
486_2	AQZ	NA	NA	NA	NA	0.020	NA	NA	NA	NA
486_2	ATX	1.425	NA	NA	NA	NA	0.450	2.930	3.785	0.780
486_2	AZN	0.110	NA	0.05	NA	NA	0.040	NA	NA	NA
486_2	CSS	4.800	1.80	NA	NA	NA	NA	0.180	0.230	NA
486_2	CWD	NA	NA	0.15	NA	NA	NA	NA	0.115	NA
486_2	DMO	NA	NA	NA	NA	NA	NA	NA	NA	0.130
486_2	GGW	2.595	1.20	NA	1.72	2.371	0.205	0.420	0.317	0.365
486_2	HXY	NA	NA	NA	NA	0.050	NA	NA	NA	NA
486_2	NTW	0.050	NA	NA	NA	0.010	NA	NA	NA	NA
486_2	OEQ	NA	NA	0.10	NA	0.150	0.220	0.100	0.410	NA
486_2	OOY	0.200	NA	NA	NA	NA	NA	NA	0.045	NA
486_2	OWP	NA	NA	NA	0.06	NA	NA	NA	NA	NA
486_2	SSX	0.050	NA	NA	NA	NA	NA	NA	NA	NA
486_2	ZOT	0.050	NA	NA	NA	0.600	NA	0.160	0.060	NA
486_3	AJZ	NA	NA	NA	NA	0.160	NA	0.020	0.135	0.525
486_3	ATX	0.050	NA	NA	NA	0.000	NA	NA	0.075	NA
486_3	AZN	NA	NA	NA	NA	NA	0.050	NA	NA	NA
486_3	CSS	NA	NA	NA	NA	0.000	0.010	NA	NA	NA
486_3	CVD	NA	NA	NA	NA	0.000	NA	NA	NA	NA
486_3	CWD	NA	NA	NA	NA	0.110	NA	NA	NA	NA
486_3	DMO	NA	NA	0.73	NA	NA	NA	NA	NA	NA
486_3	GGW	0.050	0.06	0.10	0.52	1.000	0.190	0.045	0.184	1.200
486_3	HXY	NA	NA	NA	NA	0.250	NA	NA	NA	NA
486_3	NTW	NA	NA	NA	NA	0.110	0.050	NA	0.090	0.700
486_3	PFR	NA	NA	NA	NA	0.000	NA	NA	NA	NA

Table 8 continued: Summary of catch weight (kg) of VME species recorded by scientific observers in Subarea 48.6 since 2012/13 fishing season.

RB	Taxon	2013	2015	2016	2017	2018	2019	2020	2021
486_4	AJZ	0.05	NA	NA	0.30	0.20	1.270	0.105	2.850
486_4	ATX	1.10	0.05	0.950	0.10	1.05	1.340	3.744	0.100
486_4	AXT	NA	NA	0.001	0.01	NA	NA	NA	NA
486_4	AZN	0.02	NA	NA	NA	0.01	NA	NA	NA
486_4	BZN	NA	NA	NA	NA	NA	0.155	0.015	0.150
486_4	CNI	NA	NA	NA	NA	NA	NA	NA	0.050
486_4	CSS	0.01	NA	NA	0.05	NA	0.120	0.306	NA
486_4	CVD	0.05	NA	NA	0.05	NA	NA	0.029	NA
486_4	CWD	0.23	NA	NA	NA	NA	0.555	0.060	NA
486_4	DMO	0.01	0.95	NA	NA	0.61	2.025	0.780	NA
486_4	GGW	5.22	0.02	0.030	0.13	0.36	0.095	2.290	0.700
486_4	HQZ	0.01	NA	NA	NA	NA	NA	NA	NA
486_4	HXY	0.41	NA	NA	0.05	0.20	0.080	0.014	NA
486_4	NTW	1.20	0.65	0.030	0.35	1.25	0.570	3.674	0.220
486_4	OOY	NA	NA	NA	NA	NA	0.030	NA	NA
486_4	OWP	NA	NA	0.010	NA	NA	NA	NA	NA
486_4	PFR	NA	NA	NA	0.01	NA	NA	NA	NA
486_4	SSX	NA	NA	0.030	NA	NA	0.400	0.075	NA
486_4	URX	NA	NA	NA	NA	NA	0.175	NA	NA
486_4	ZOT	0.05	NA	NA	0.11	NA	NA	NA	NA
486_5	AJZ	NA	NA	NA	NA	NA	0.615	0.335	1.290
486_5	ATX	NA	NA	NA	NA	NA	NA	4.170	0.100
486_5	CSS	NA	NA	NA	NA	NA	0.350	0.240	NA
486_5	CVD	NA	NA	NA	NA	NA	0.040	NA	NA
486_5	CWD	NA	NA	NA	NA	0.04	0.605	0.380	2.200
486_5	DMO	NA	NA	NA	NA	NA	0.865	0.815	NA
486_5	GGW	NA	NA	NA	1.27	NA	NA	1.335	0.300
486_5	NTW	NA	NA	NA	0.02	0.61	2.110	3.703	8.685
486_5	OEQ	NA	NA	NA	NA	0.14	NA	0.030	NA
486_5	OOY	NA	NA	NA	NA	NA	0.035	NA	0.670
486_5	SSX	NA	NA	NA	NA	0.10	0.105	0.405	0.300
486_5	UNK	NA	NA	NA	NA	NA	0.125	NA	NA
486_5	URX	NA	NA	NA	NA	NA	0.280	0.125	NA

Achievement of milestones for research objectives

Objective 1: An assessment of the stock status of *D. mawsoni*.

CASAL models for *D. mawsoni* at Subarea 48.6 have been developed and reported in following papers;

- T. Okuda (2018) Preliminary results of stock estimation for D. mawsoni using CASAL in the research block 48.6_2. Document WG-FSA-18/72.,
- K. Sawada and T. Okuda (2019) Progress on the integrated stock assessment by CASAL for Antarctic toothfish Dissostichus mawsoni in Subarea 48.6. Document WG-FSA-2019/21., and
- Y. Osawa, K. Sawada, and T. Okuda (2021) Preliminary progress on the integrated stock assessment by CASAL for Antarctic toothfish Dissostichus mawsoni in Subarea 48.6. Document WG-FSA-2021/XX.

In 2020/21 fishing season, CASAL model have been updated with latest data up to 2019/20 fishing season. Otoliths collected in previous fishing season will be aged to increase sample size of aging data to get concrete annual age length keys.

An updated CASAL model was constructed for *Dissostichus mawsoni* at the Subarea 48.6, using the data collected from blocks 2 - 5. The updated model showed some improvements, especially in the age/tagging related assumptions. On the other hands, the model indicated some unreliable results, which should be carefully considered before it moves on to the further step. Additional data or arrangement of parameters of CASAL model might help us to improve the model quality to conduct the future stock assessment of *D. mawsoni* in Subarea 48.6.

Objective 2: Improving the knowledge about growth of *D. mawsoni*.

From 2012/13 fishing season, Japan has conducted works on *D. mawsoni* age and growth with otolith readings in cooperation with Secretariat and other members (especially NZ colleagues). From 2018/19 fishing season, Japanese and Spanish readers are conducting aging works for more than 500 otoliths, and starting evaluating reading results among them but due to COVID it has not been possible to finalize the age estimates. It is expected to continue with this work in the coming months.

Previously, this multi-member research program updated growth parameters in annual progress report (WG-SAM-14/01, WG-FSA-14/17, WG-SAM-15/06, WG-FSA-15/16 Rev1, WG-SAM-16/07, WG-FSA-16/32 Rev1). In 2018/19 fishing season, Age Length Keys and growth model parameters were updated and presented in WG-SAM-2019/36 (Okuda and Sarralde Vizuete 2019).

From the 2018/19 season, a total of 293 otoliths have been read by Spain in order to estimate the age in length of the *D. mawsoni* specimens (female: 139, male: 154) at Subarea 48.6. Preliminary results are shown in Figure 8, where age-length values by sex are plotted together with the 95% confidence interval of the age-length curve used in the Ross sea assessment (CCAMLR, 2015), to help visually.

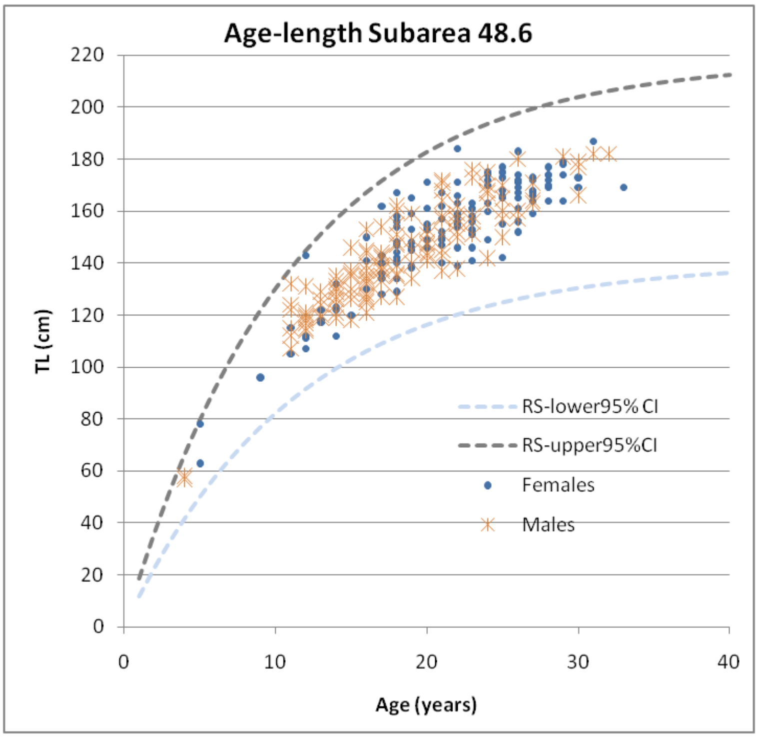


Figure 8: Age-length relationship of *D. mawsoni* in Subarea 48.6 derived from Spanish aging works during 2018/19 fishing season. Dotted curves are the 95% confidence interval from Ross sea assessment.

Objective 3: Improving the knowledge about population structure of *D. mawsoni*.

Previously, hypothesis testing of stock structure including toothfish movement has been discussed in annual reports of this research program (WG-SAM-14/01, WG-SAM-14/10, WG-FSA-14/17, WG-SAM-15/06, WG-FSA-15/16 Rev1, WG-SAM-16/07, WG-FSA-16/32 Rev1). In February 2018 the first Workshop on *D. mawsoni* took place in Berlin, we wrapped up the cumulative knowledge about the stock structure of *D. mawsoni* in 48.6 and surrounding areas (WS-DmPH-18/06), and three potential stock hypotheses for *D. mawsoni* in the Atlantic and adjacent regions of the Southern Ocean were proposed in WG-SAM-18/33 (Söffker et. al. 2018).

In the 2018/19 fishing season, movements of tagged *D. mawsoni* were examined in relation to life history hypotheses at Subarea 48.6 (WG-FSA-19/05). Most of long-distance movements occurred in westward direction along continental shelf, which may support the single Atlantic population hypothesis (Söffker et al., 2018). This year we conducted an updated analysis of long-distance movements of tagged D. mawsoni that were released or recaptured in 48.6. As for east-west movements, between-subareas movements occurred occasionally (Fig. 9). Specifically, five tags showed westward movements, i.e. three tags moved from 58.4.2 to 48.6, one tag from 58.4.1 to 48.6, and one tag from 48.6 to 48.2. One tag showed eastward movement from 48.6_5 to 48.6_4. As for north-south movements, we could finally collect data that support the hypothesis on migrations between the shelf areas (feeding ground) and northern areas (spawning ground), although data are only northward movements. Two tags moved from 58.4.2_1 to 48.6_2, one tag from 48.6_4 to 48.6_3, and one tag from 48.6_5 to Subarea 48.2. Information on such north-south movements is important to develop the structure of CASAL model in 48.6. The updated analysis also supports the single Atlantic population hypothesis.

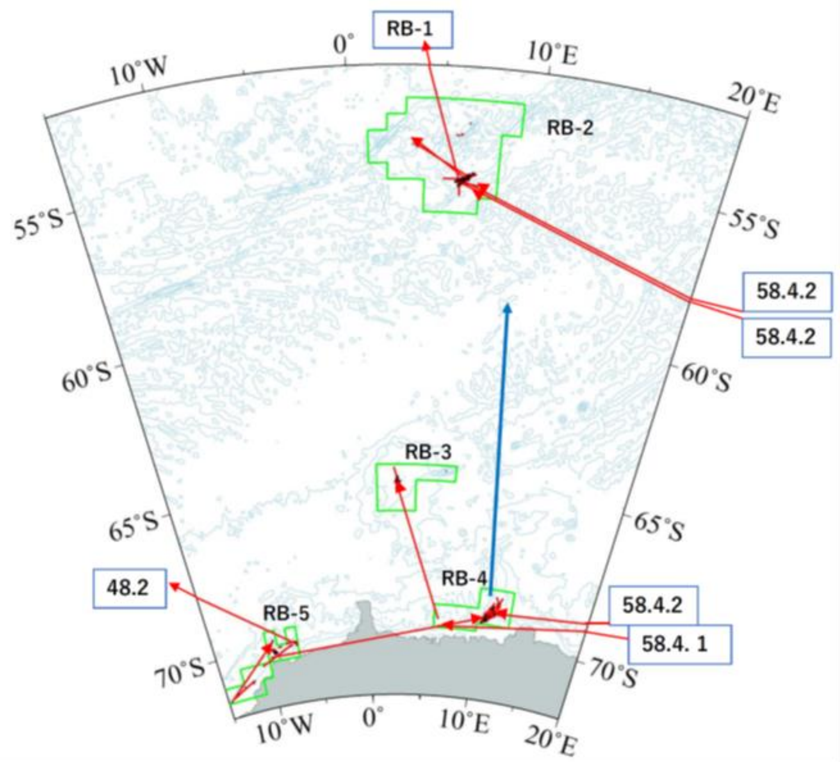


Figure 9. Net movement of tagged D. mawsoni based on between-season recaptures during the period of 2008-2021. Red and blue lines indicate movements of ordinary tag and PSAT tag, respectively. RB indicates research block, e.g. RB-2 indicates 48.6_2.

Spain deployed 6 satellite pop-up tags (PSATs) in *D. mawsoni* in the 2018/19 fishing season (Fig. 10). Althoug 4 tags popped-up, it has not been possible to obtain the stored information, probably due to the presence of ice.

On the other hand, 3 *D. mawsoni* have been tagged by Japan in the 2019/20 season with a pop up electronic PSAT tags, 2 within the 48.6_3 and 1 in 48.6_4. One PSAT successfully sent data in February 2021, which showed northward migration from 48.6_4 to around 59˚ S (Fig. 9). This data also supports the hypothesis of north-south migration of this species.

Figure 10: A picture of PSAT deployed in *D. mawsoni* by F/V Tronio in Subarea 48.6 during 2018/19 fishing season.

For the otolith microchemical analysis of *D. mawsoni*, we are collaborating with Chinese colleague (Prof. Guoping Zhu; WG-FSA-18/75). His group are building experimental procedures under the suggestions from the well-experienced international scientists, but the morphology of samples was analyzed and presented in the WG-FSA (WG-FSA-2019/61). In 2019 a study in collaboration with the University of La Laguna (Spain) has been made with the aim of analysing the possible existence of a population structure for the Antarctic toothfish *D. mawsoni* in four different areas in the Atlantic sector and one in the Indian sector of the Southern Ocean and, if applicable, to assess the migration rate between them. For this purpose, the molecular variation between individuals of the possible stocks were studied for three mitochondrial DNA fragments: Cyt b, ND2 and 16S rRNA.

50 samples of muscle tissue from Antarctic toothfish from 5 different locations. Ten of them originating from Division 58.4.1 and 40 from Subarea 48.6, itself subdivided into four blocks (research blocks 2-5). Of the 2,101 nucleotide positions analyzed, only 15 were variable (0.7%). The research block 5 of Subarea 48.6 showed the greatest genetic variation (8 of the 15 variants found).

On the other hand, nucleotide diversity showed very low values, ranging from 0.027 % (ND2 and 16S rRNA) to 0.048 % for cyt b, which are similar to those obtained by Kuhn and Gaffney (2008) for these same markers.

In summary, the results of this work indicate that there is no significant genetic differentiation between the sampled populations, which could be explained by the existence of a significant migration rate between them or by a low rate of nucleotide substitution. In this sense, our results agree with those recently published by Maschette et al. (2019), based on the analysis of 10,303 SNPs in 535 individuals of D. mawsoni, who conclude that there is no population structure, ruling out the existence of genetically distinct breeding populations in this species.

However, special mention should be made of the results obtained for the research block 5 of Subarea 48.6, which shows a significantly higher genetic variability than the rest of the blocks sampled for this work. However, the small sample sizes of this study make it necessary to take these results with caution. Thus, the results of analyses with a larger sample size may differ from those found in this study.

Objective 4: Investigating ecological traits of *D. mawsoni*.

Previously, this multi-member research program updated length-weight relationship and maturity ogive parameters in annual progress report (SAM-14/01, FSA-14/17, SAM-15/06, FSA-15/16 Rev1, SAM-16/07, FSA-16/32 Rev1, WG-FSA-18/71, WG-SAM-2019/36).

A total of 511 *D. mawsoni* were sampled for stomach contents onboard the Tronio during the 2018/19 season in subarea 48.6, 337 in 2019/20 and 149 in 2020/21. The Stomach index (from 0 to 4) results are shown in Table 11. 114 out of 511 specimens had the stomach full. Japan also have started a collaboration about examining stomach contents with Korean scientists.

Table 11: Stomach index of D. mawsoni collected by Tronio in Subarea 48.6 during 2018/19, 2019/20 and 2020/21 fishing season.

Fullness	Fullness index	N 2019	N 2020	N 2021
Empty	0	298	184	62
>1/4 filled	1	69	61	30
half full	2	56	41	28
3 /4 filled	3	21	21	12
full	4	67	30	17

Looking into big groups of prey (Fig. 11), 30 and 14% of stomach content were from invertebrates (octopuses, squids or crustaceans), while 28 and 42% were full of fishes (eelpouts, rattails, icefishes or liparids) and 42 and 44% others (rock, unidentified, offal or bait) in 2018/19 and 2019/20 fishing season, respectively.

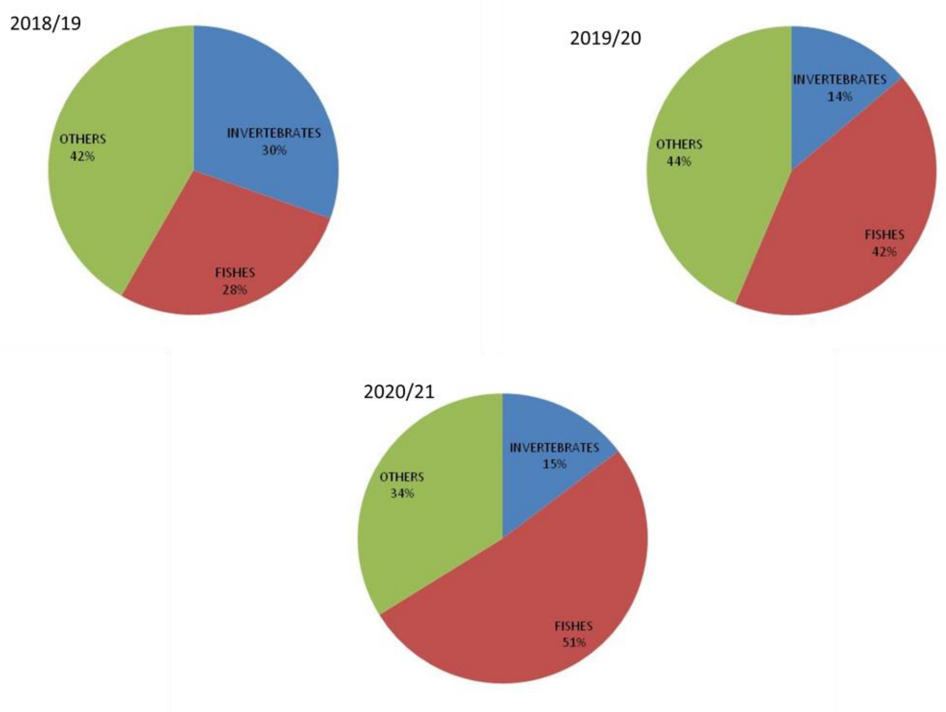


Figure 11: Percentage of prey by big group of *D. mawsoni* collected by Tronio in Subarea 48.6 during 2018/19 (top left), 2019/20 (top right) and 2020/21 (bottom) fishing season.

For quantification, the diet composition has been sampled in percentage of each prey present in the stomach. If the stomach is full with only one prey, a 100% is assigned to this prey. If more than one prey is present, the % of each prey into the sample is collected. Bait has been the most abundant item in the two first seasons while in 2020/21 they have been unidentified fishes (Figure 12). The bait used during the survey are squids and/or herrings. From invertebrates, the most abundant prey are octopuses and from fishes, rattails and icefish are the most abundant between the identified taxa.

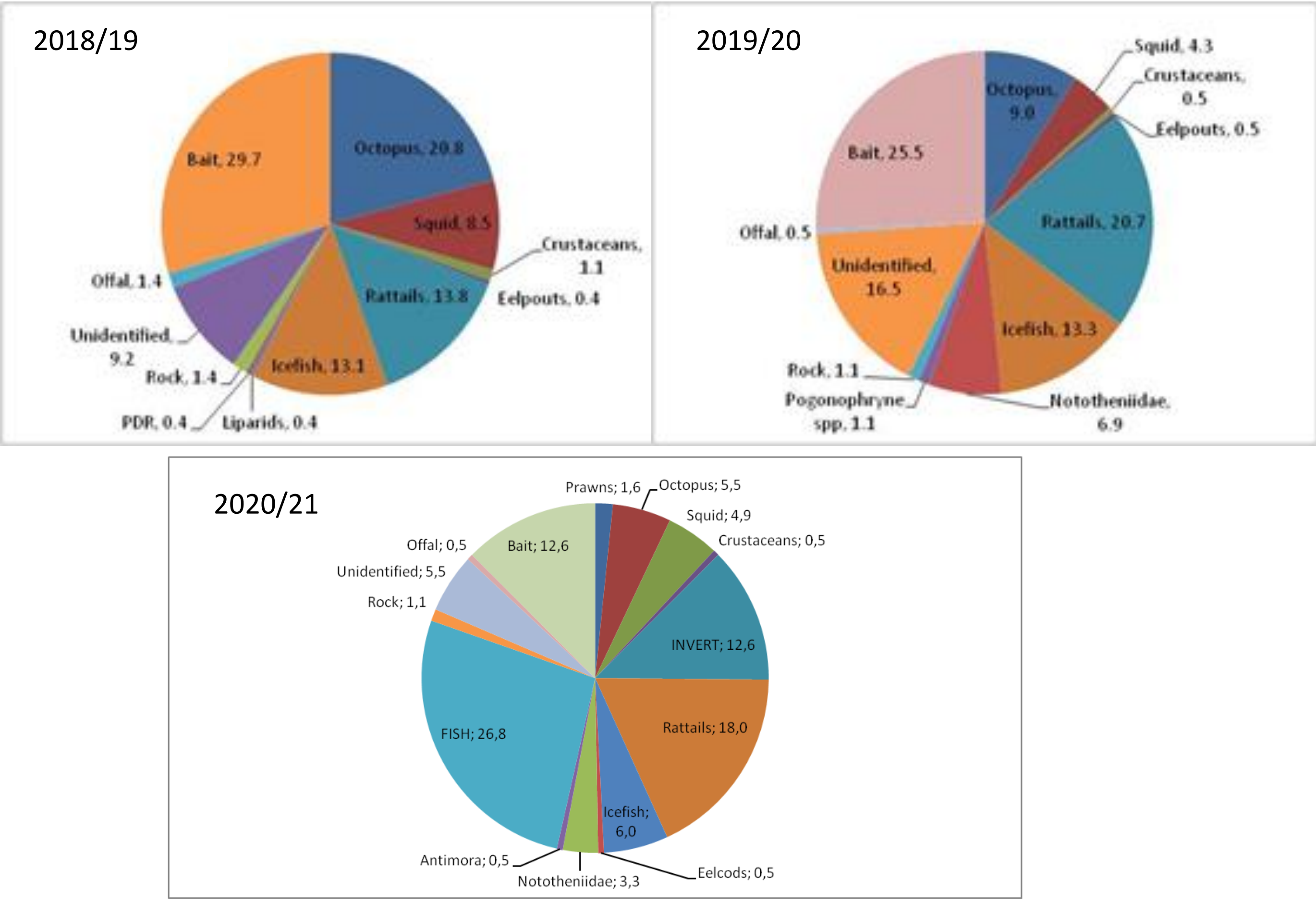


Figure 12: Diet composition in % of *D. mawsoni* collected by Tronio in Subarea 48.6 during 2018/19 (top left), 2019/20 (top right) and 2020/21 (bottom) fishing season.

Two cases in which the stomach was full of penguin remains (flipper and bones) and collected as "Unidentified" have been found in 2019/20 season as well as one case with an orange peel that has been collected as "offal" while in 2018/19 there were an stomach from another fish species and collected as "offal" as well. In 2020/21 one stomach content has been identified as offal corresponding with a spine and a fish fin.

Stomach and liver weights have been also sampled. *D. mawsoni* relationships between TL and liver weight (left) and TL and stomach weight are shown in Figure 13.

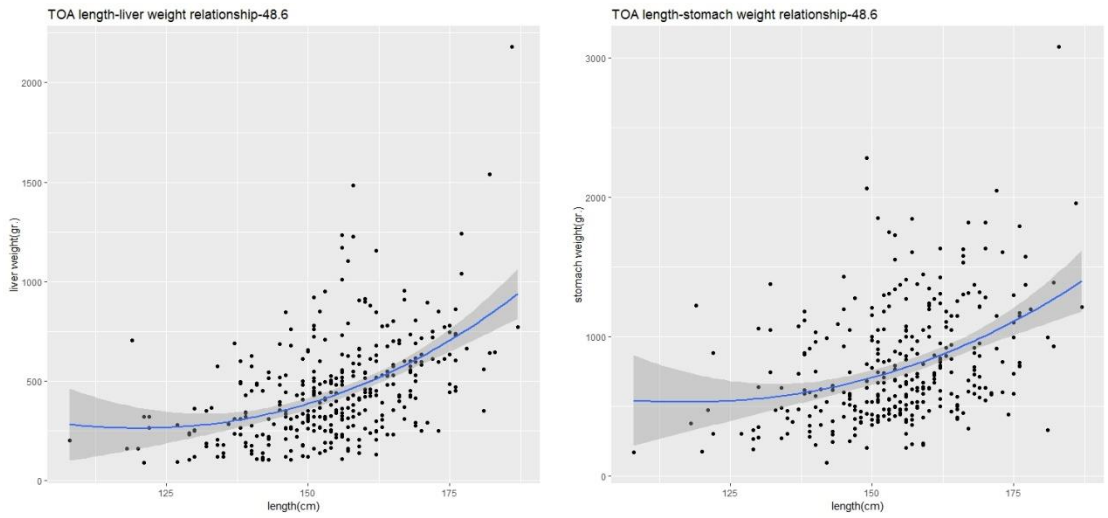


Figure 13: TL-liver weight (left) and TL-stomach weight (right) relationship of *D. mawsoni* collected by Tronio in Subarea 48.6 during 2018/19 fishing season.

Objective 5: Revealing spatio-temporal pattern of bycatch species distribution.

Previously, this multi-member research program reported spatial pattern of major by-catch fishes and VME indicators in Subarea 48.6 (WG-SAM-17/44, WG-FSA-18/70).

For bycatch fishes, statistical models have been developed to examine by-catch fish pattern in toothfish fishing operations at Subarea 48.6; conventional (non-spatial) generalized linear mixed models (GLMMs, WG-SAM-2019/09), and a spatial delta-GLMM implemented by the R package VAST (reported during WG-FSA-2020 online discussion). The spatial modeling using VAST have been improved to consider following issues suggested during WG-FSA-2020 online discussion; 1) further examination of model diagnostics, (ii) application to other research blocks, and (iii) evaluation of gear effects (document of WG-FSA-2021).

Objective 6: Improving the knowledge about Antarctic marine ecosystems.

Dr. Namba reported the series of sea ice and SST analysis as follows;

- Delegation of Japan (2015) Research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. in Subarea 48.6. WG-SAM-15/06.
- T. Namba, T. Ichii and T. Okuda (2017a) Update of analysis on sea-ice concentration of southern part of 48.6 and 58.4.2 for the new research block on expected spawning ground of TOA. WG-SAM-17/10.
- T. Namba, T. Ichii and T. Okuda (2017b) Correlation of sea surface temperature in Ross Sea, Weddell Sea and the sea off Peru for the ice analysis. WG-FSA-17/08.
- T. Namba, R. Sarralde, H. Pehlke, K. Teschke, T. Brey, S. Hain, T. Ichii, T. Okuda, S.

Somhlaba and J. Pompert (2019) Analysis of the sea-ice concentration (SIC) in Subarea 48.6, research blocks 2, 3, 4 and 5 with sea-surface temperature (SST) and statistical models. WG-SAM-2019/15.

- T. Namba, R. Sarralde, S. Somhlaba and J. Pompert (2019a) Correlation of sea-surface temperature (SST) with sea-ice concentration (SIC) between Subarea 48.6 and other areas such as Ross Sea, Weddell Sea. WG-FSA2019/48.
- T. Namba, R. Sarralde, S. Somhlaba and J. Pompert (2019b) Possibility of predicting sea-ice concentration (SIC) in research block (RB) 48.6-5 (Southern part of Subarea 48.6) using sea surface temperature (SST) in RB 48.6-2 (Northern part of 48.6). WG-FSA-2019/49.
- T. Namba, R. Sarralde, T. Ichii, T. Okuda, S. Somhlaba and J. Pompert (2021) 2021 updated analysis of the sea ice concentration (SIC) in research blocks 4 (RB4), and 5 (RB5) of Subarea 48.6 with sea surface temperature (SST) and windsWG-SAM-2021/21.

F/V Tronio conducted CTD deployments in subarea 48.6 during February-March in both 2020 and 2021 seasons using two Valeport FastCTD Profilers (Fig. 14). There were 14 CTD stations (4 stations in RB5, 3 in RB4, 2 in, 5 in RB2) in 2020 and 13 CTD stations (5 stations in RB5, 8 in RB4, 0 in RB3) in 2021 from the 30 stations and 15 stations sampled respectively. The profile of 48.6_3 has an abrupt temperature spike in the subsurface of 0-200m that decreases sharply to a minimum of -1.2 °C at approx. 50m and increases again to 1.0 °C at 120m. The minimum temperature of -1.2 °C in 48.6_3 is higher than -1.7 °C of 48.6_4 and 48.6_5 probably because 48.6_3 was not covered by ice at the time. The profiles of 48.6_4 and 48.6_5 are similar except fluctuations in the subsurface layers down to 120m in 48.6_4 where it first reaches the minimum temperature (-1.8°C) until approx. 370m and then increases abruptly to 0.7 °C at 700m. According to the T-S diagram with density (isopycnal), the diagram of 48.6_3 has a U shape while that of 48.6_5 has a reverse L shape. 48.6_4 has a shape in between U and reverse L. The T-S curve with density in 48.6_4 and 48.6_5 indicates that the density field is stable because the density increases with the depth, so vertical mixing probably does not happen frequently.

In 2021, CTD data only in RB4 and RB5 are available. They have almost the same characteristics as in 2020.

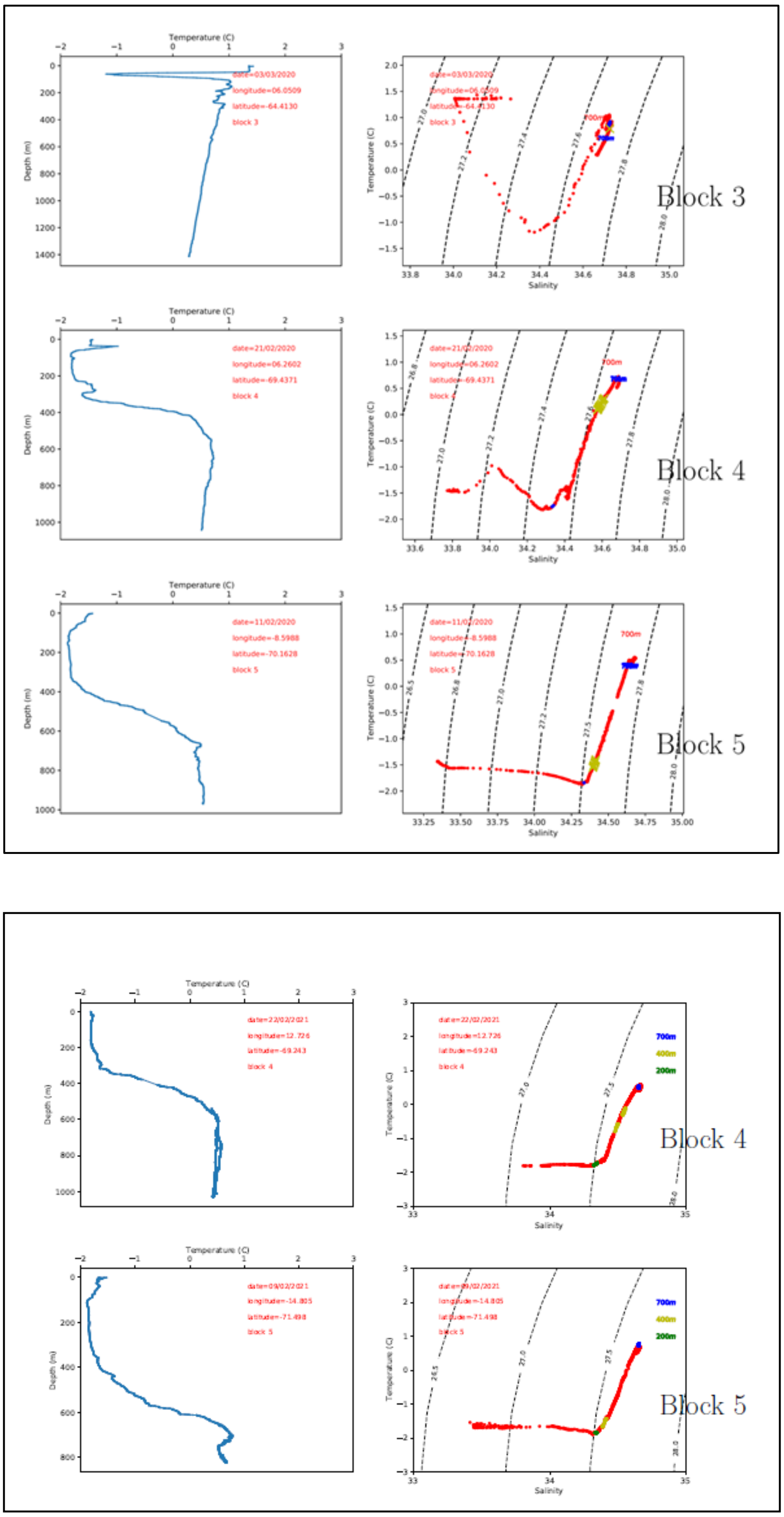


Figure 14: T profiles (of depth) and T-S diagram of CTDs with density by RB deployed by Tronio in 2020 (top) and 2021 (bottom)

The bottom video camera system (GoPro camera and lights in GroupInc housing; Fig. 15) was deployed at 14 locations in Subarea 48.6 by Tronio, from 1300m to 1600 m of depth in 2020 (Fig. 16) and 17 times in 2021. The video camera is attached to the gear on the buoy line close to the initial weights. Most of the images show a seabed composition of superficial sedimentary layer on hard rock, and probably coral-dead framework (images a-d in Fig. 17) and some big rocks populated with invertebrate organisms, hard corals, sponges, *Crinoidae* and *Ophiuridae* among them (images e-f).

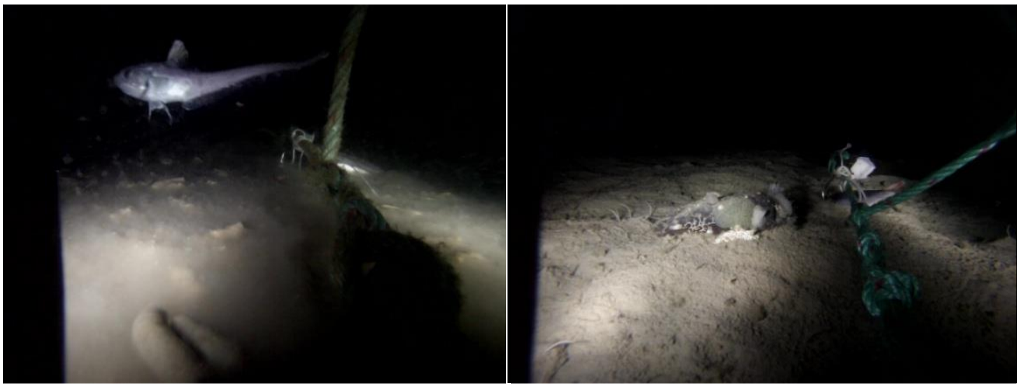
The videos show still images, except for the first moments when the gear is being stabilised in the seabed. Macrourids, shrimps, *Ophiura* and other unidentified small fishes can be seen lurking but no toothfish around.

Figure 15: Benthic camera and light (left) and Benthic camera plate (right) deployed by Tronio at Subarea 48.6 during 2018/19 fishing season.

Figure 16: Location of the bottom video camera deployed by Tronio in Subarea during 2019/20 fishing season.

a) b)

c) d)



e) f)

Figure 17: Photographs extracted from the video footage of the sea bottom in Subarea 48.6. The pictures show; a) bait in a dead coral framework, b) a bedrock with surrounding flats covered by thin biogenic sediments and a crinoid attached to a rock , c) a Macrourid species, d) a colonial ascidian in a sedimentary seabed with coral rubble, e) rock with *Ophiuridae*, sponges and *Scleractinian* and f) *Crinoid* and *Scleractinian*.

Objective 7: Investigating effects of depredation.

Observations of marine mammals have been very scarce in Subarea 48.6. There were 21 sightings of marine mammals during the 48.6 fishing activities (Figure 18) from three species of baleen whales and a crabeater seal (*Lobodon carcinophagus*) that was resting on ice. Minke whale (*Balaenoptera acutorostrata*) and Humpback whale (*Megaptera novaeangliae*) were the most abundant and only one sighting was made on fin whale

(*Balaenoptera physalus*). Only three sightings in 2021, one is probably a sperm whale (*Physeter catodon*), one Humpback whale and the last being a *Balaenopteridae* unidentified.

There is no evidence of marine mammals depredation on the catches in this subarea during the three last fishing seasons (2018/19-2020/21).

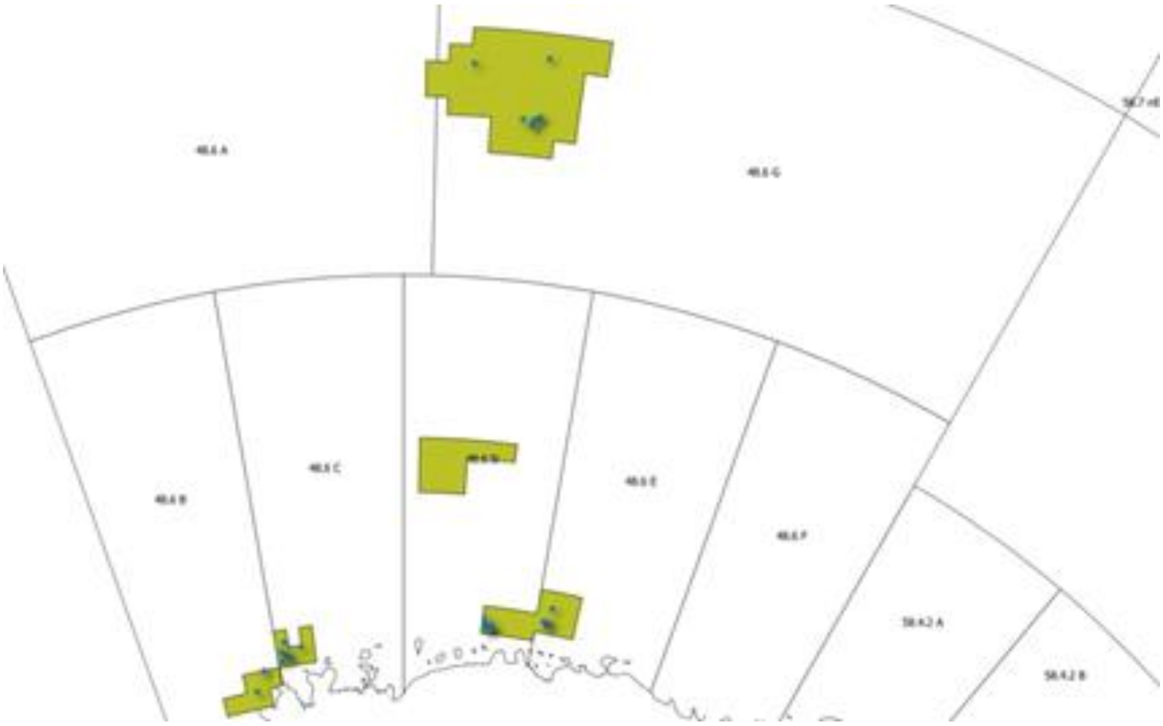


Figure 18: Location of marine mammal sightings reported in Subarea 48.6 during 2018/19-2019/20 fishing seasons.

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Appendix

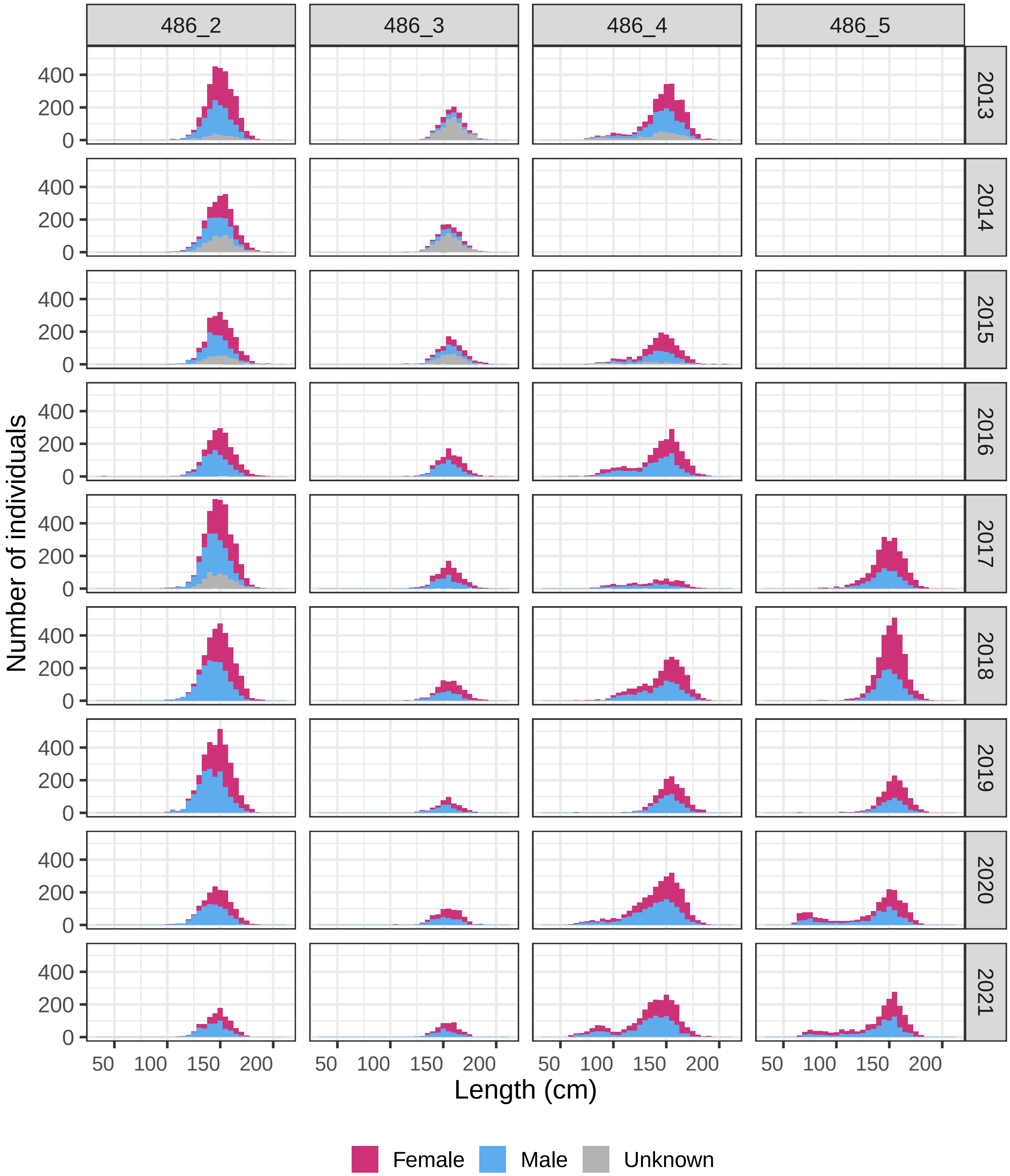

Figure A1: Length distribution by sex for *D. mawsoni* at Subarea 48.6 since 2012/13 fishing season.

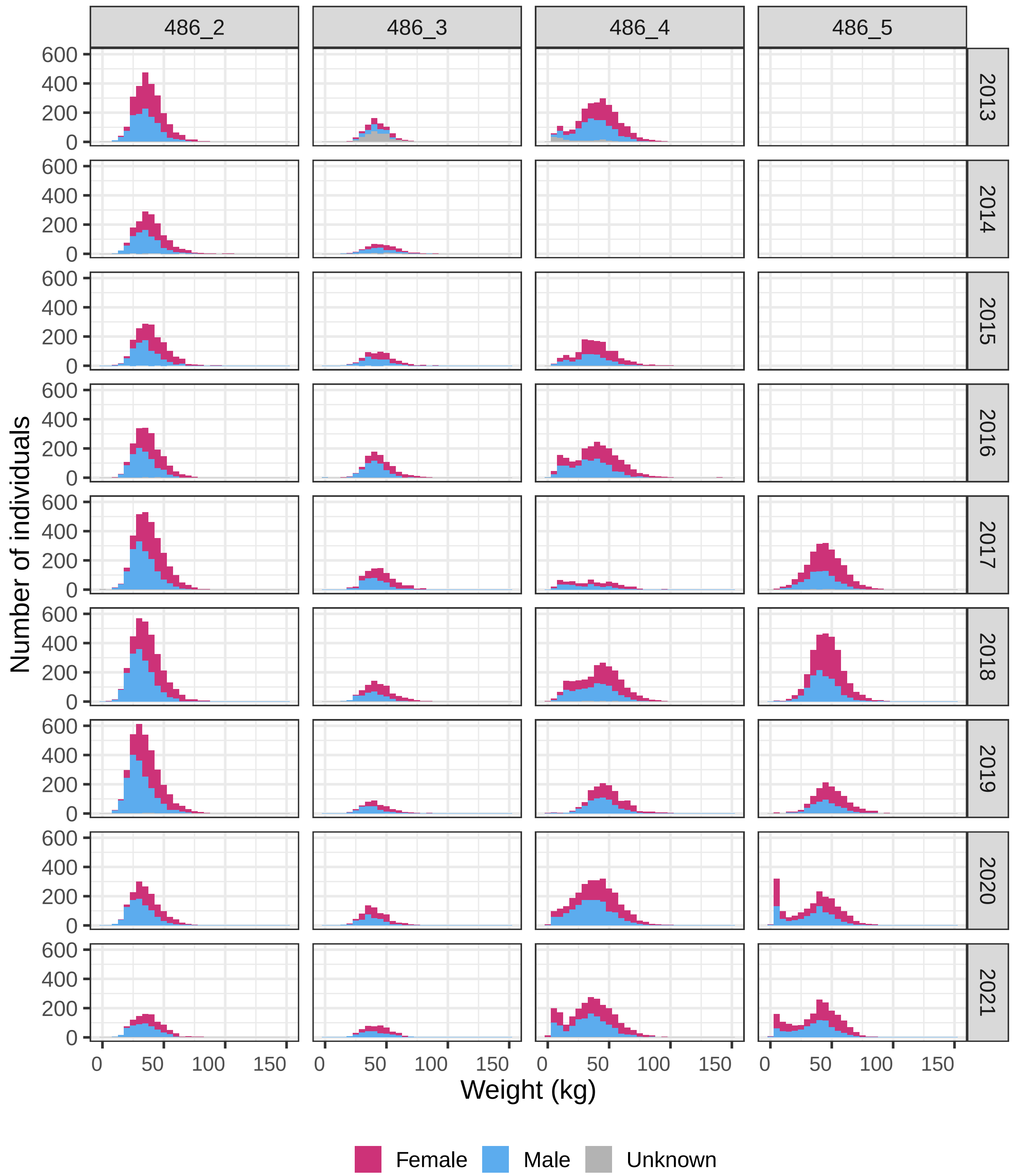

Figure A2: Weight distribution by sex for *D. mawsoni* at Subarea 48.6 since 2012/13 fishing season.

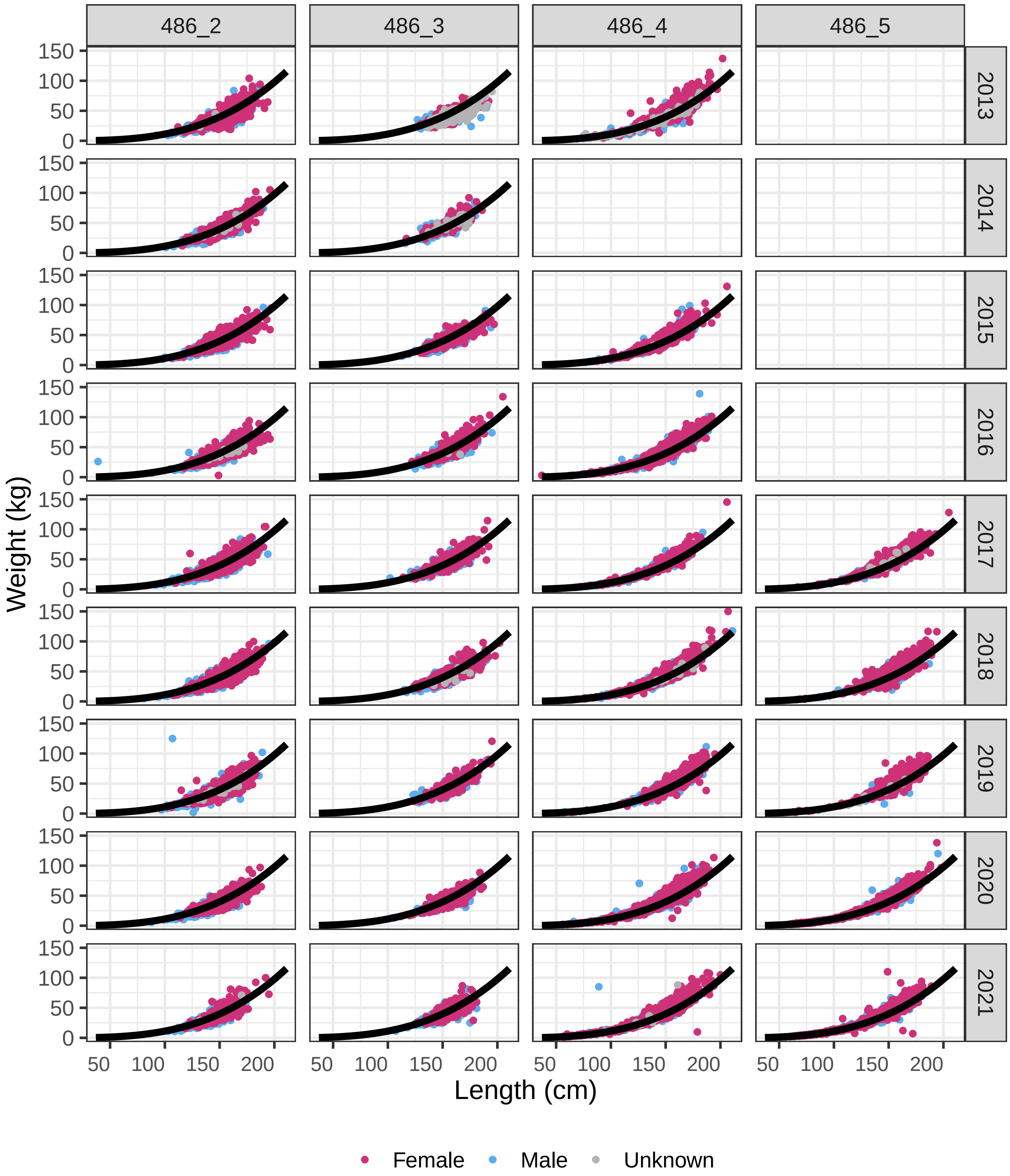

Figure A3: Length-weight relationship of *D. mawsoni* at Subarea 48.6 since 2012/13 fishing season. Black line is the non-linear regression of length-weight relationship common to the four research blocks. The weight of *D. mawsoni* caught at Subarea 48.6 during all fishing season was modelled as a non-linear function and predicted by the following formula: $Weight = 6.377 * 10^{-6} * Length^{3.123}$.

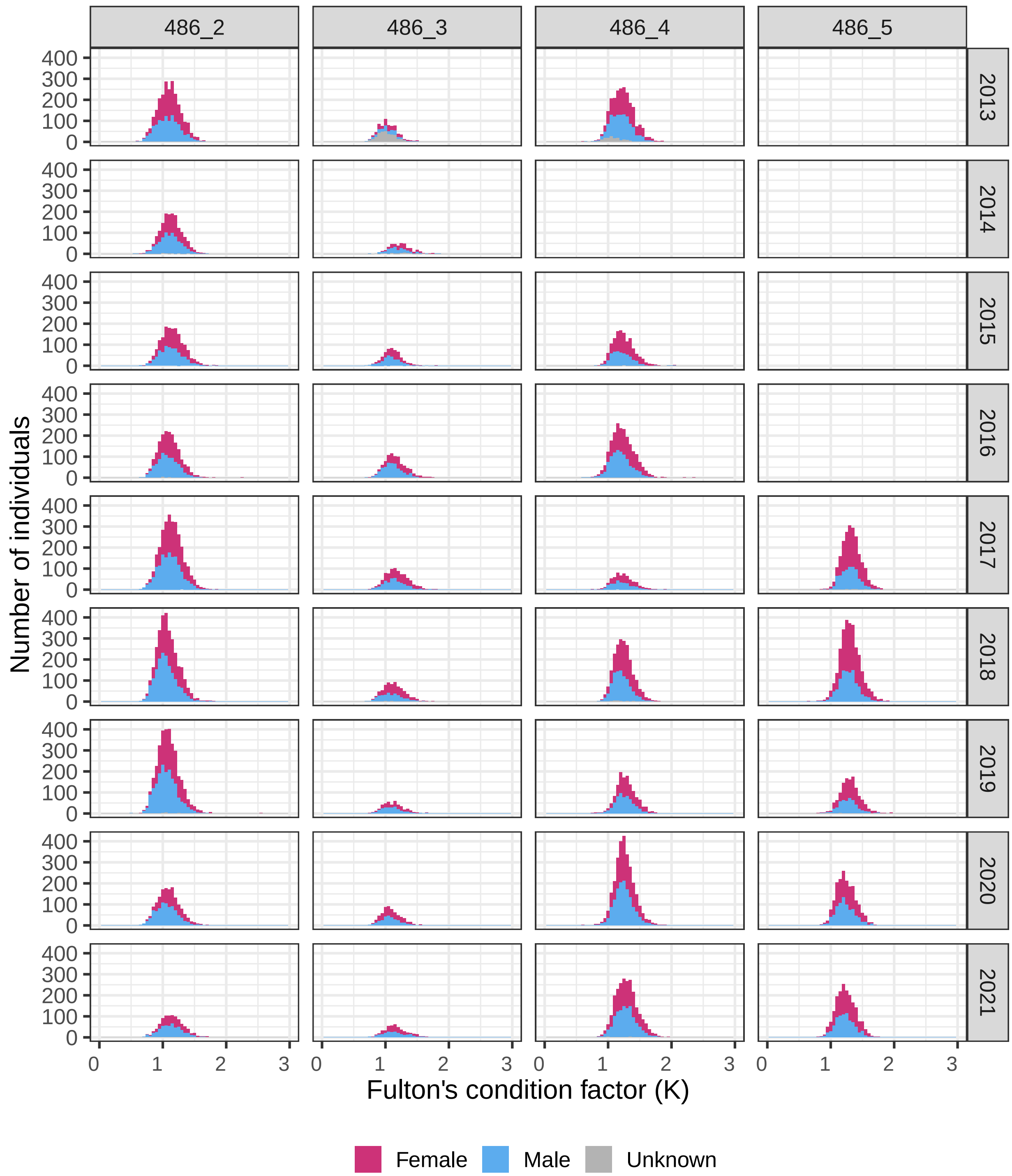

Figure A4: Fulton's condition factor ($K = Weight(t)/Length(cm)^3$) distribution of *D. mawsoni* at Subarea 48.6 since 2012/13 fishing season. To indicate the histogram, four individuals with > 3 K are removed from the figures.

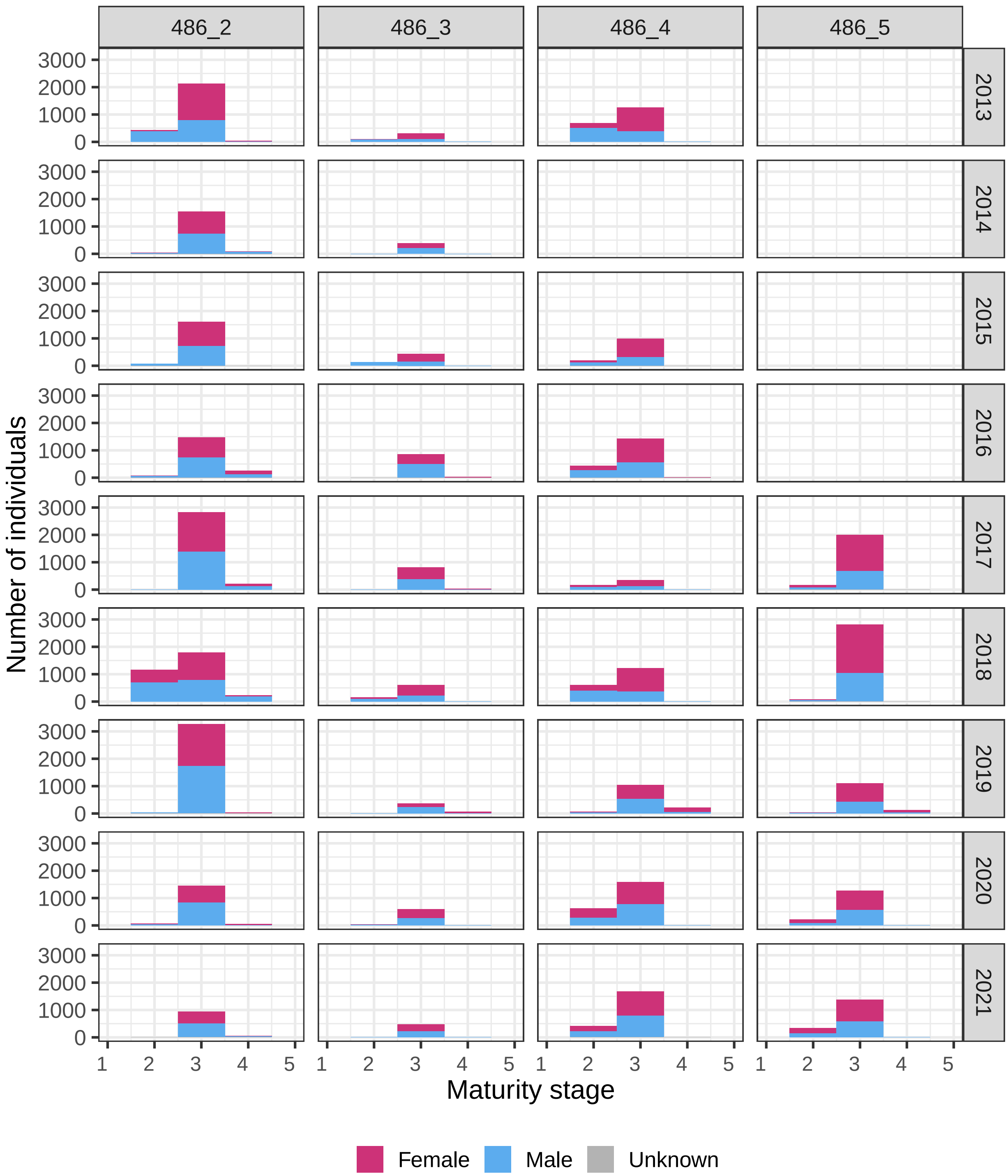

Figure A5: Maturity stage distribution of *D. mawsoni* at Subarea 48.6 since 2012/13 fishing season.

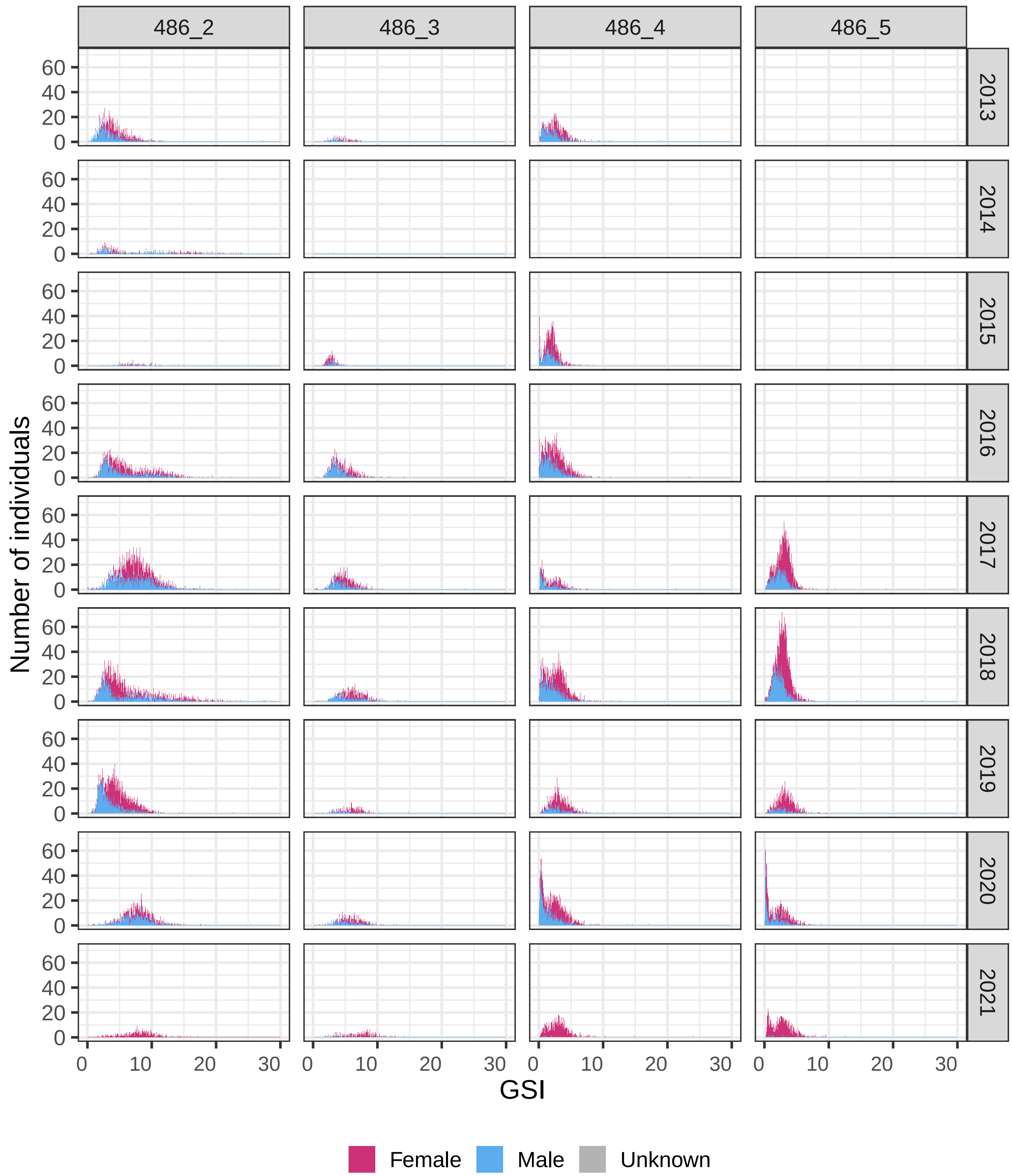

Figure A6: Gonadsomatic index (GSI) distribution of *D. mawsoni* at Subarea 48.6 since 2012/13 fishing season. To indicate the histogram, nine individuals with > 30 GSI are removed from the figures.

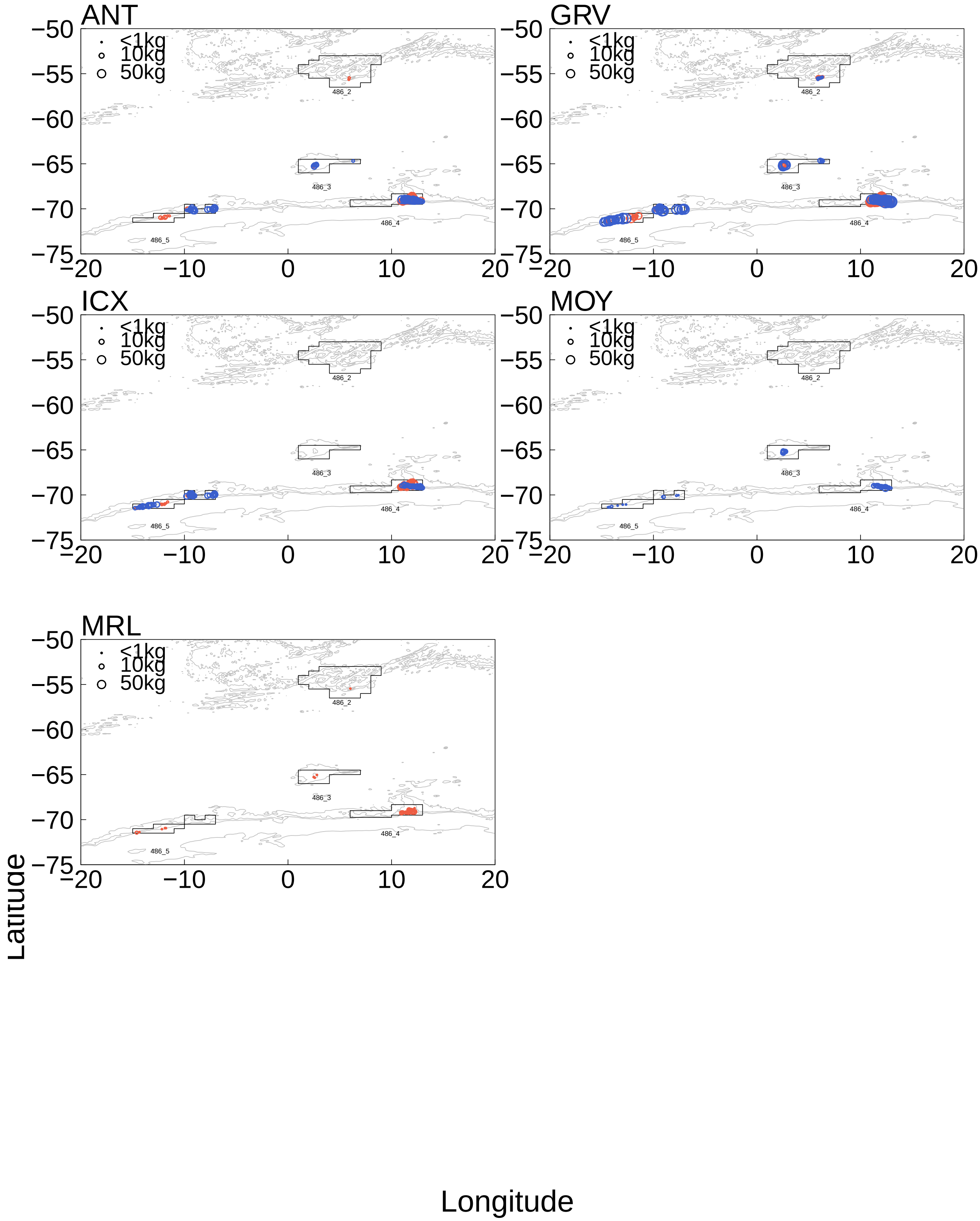

Figure A7: Map of common non-target species which are recorded more than 20 individuals in C2 at Subarea 48.6 in the 2020/21 fishing season. Size of rings represent the number of bycatch fish. Color of rings indicates the difference of vessel; sky blue: Tronio, red: Shinsei Maru No.3. Black lines = CCAMLR Research Blocks, grey line = bathymetry contours 1000, 2000, and 3000 m obtained by ETOPO1.

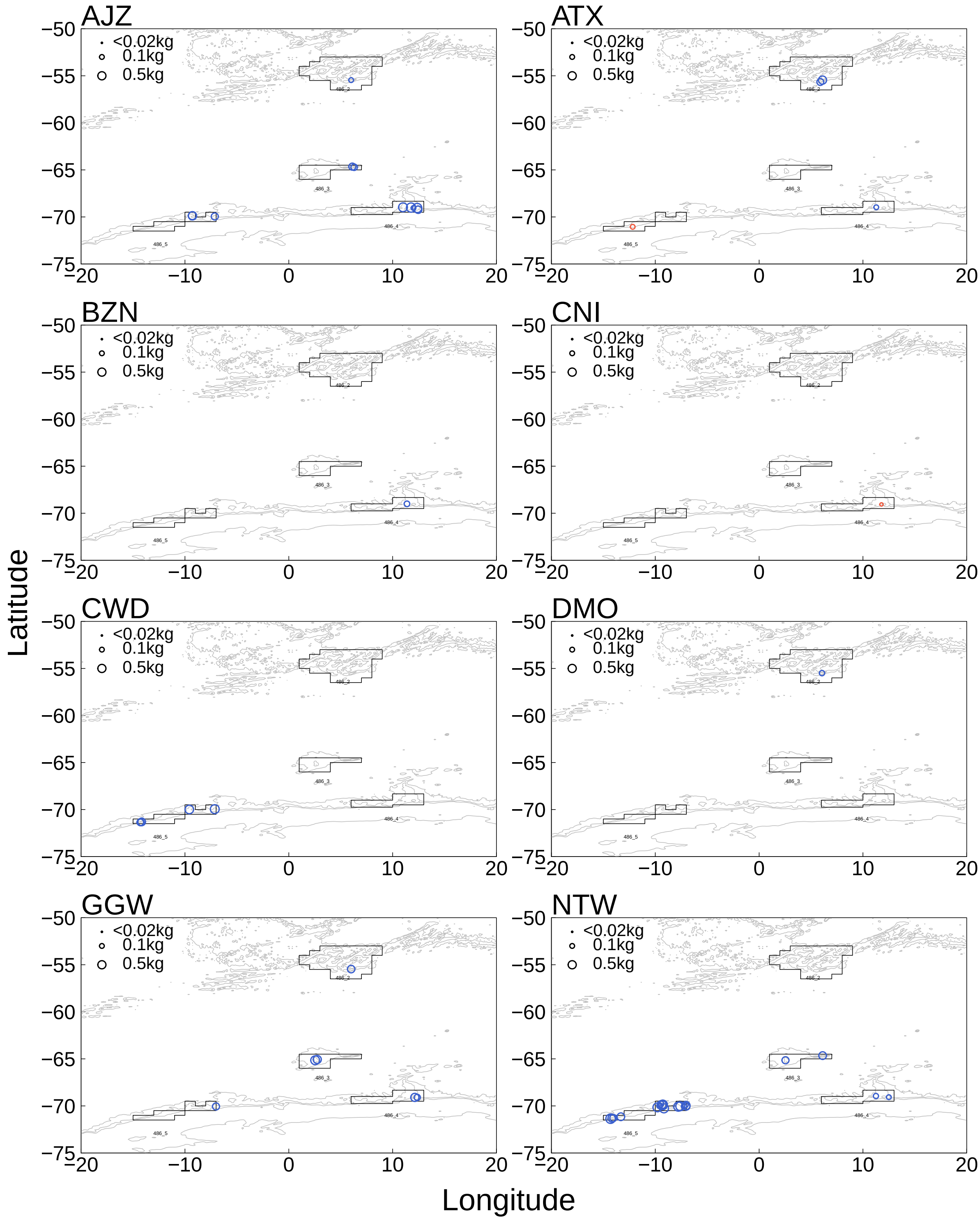

Figure A8: Map of observed VME indicator species hauled positions at Subarea 48.6 in the 2020/21 fishing season. Size of rings represent the weight of VME indicators. Color of rings indicates the difference of vessel; sky blue: Tronio, red: Shinsei Maru No.3, green: Koryo Maru No.11. Black lines = CCAMLR Research Blocks, grey line = bathymetry contours 1000, 2000, and 3000 m obtained by ETOPO1.

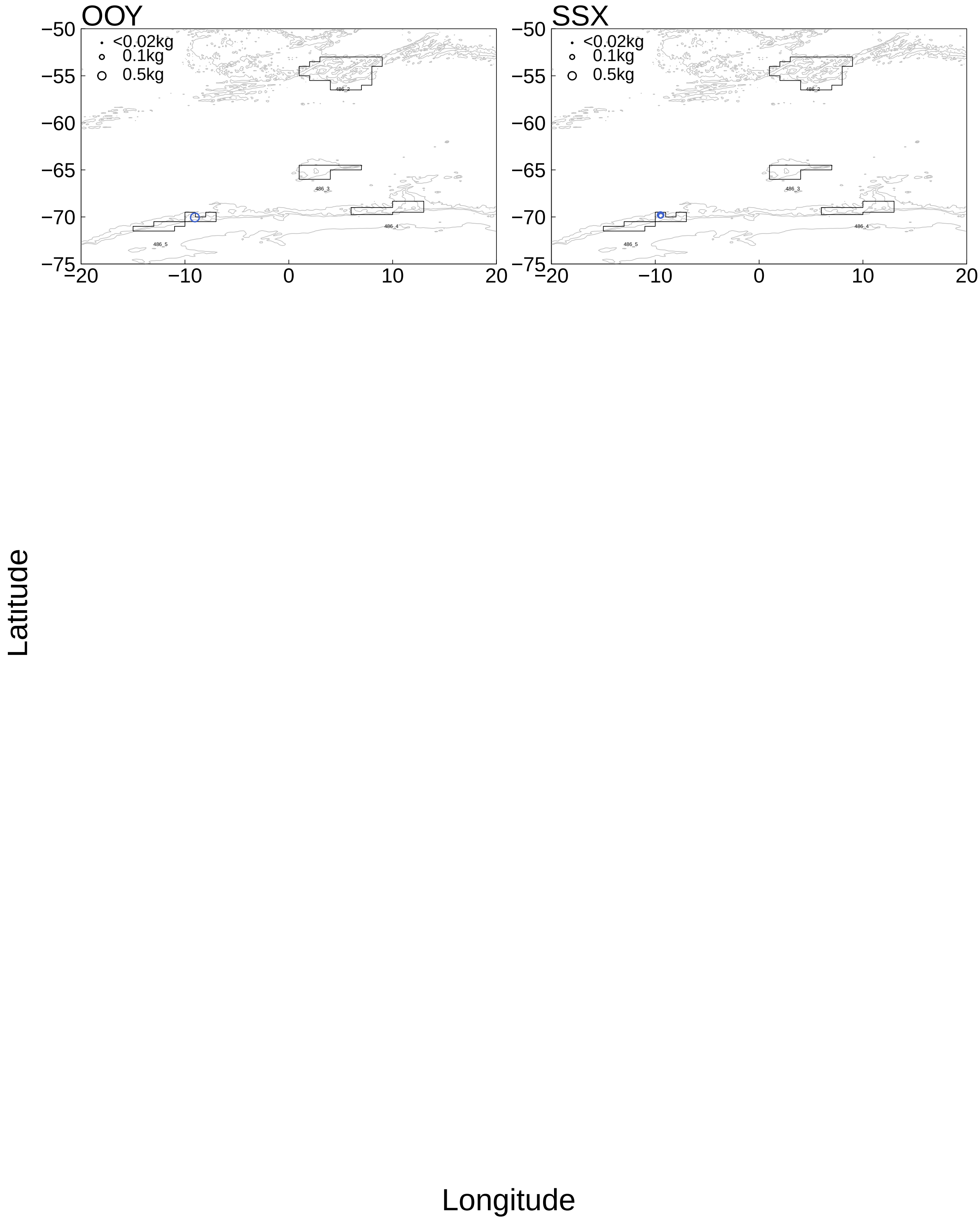

Figure A9: Map of observed VME indicator species hauled positions at Subarea 48.6 in the 2020/21 fishing season (continued). Size of rings represent the weight of VME indicators. Color of rings indicates the difference of vessel; sky blue: Tronio, red: Shinsei Maru No.3, green: Koryo Maru No.11. Black lines = CCAMLR Research Blocks, grey line = bathymetry contours 1000, 2000, and 3000 m obtained by ETOPO1.